THE NERVOUS SYSTEM,

ANATOMICAL AND PHYSIOLOGICAL:

IN WHICH

THE FUNCTIONS OF THE VARIOUS PARTS OF THE BRAIN

ARE FOR THE FIRST TIME ASSIGNED;

AND TO WHICH IS PREFIXED
SOME ACCOUNT OF THE AUTHOR'S EARLIEST DISCOVERIES,
OF WHICH THE MORE RECENT DOCTRINE OF BELL, MAGENDIE, ETC.
IS SHEWN TO BE AT ONCE A PLAGIARISM, AN INVERSION, AND A BLUNDER
ASSOCIATED WITH USELESS EXPERIMENTS,
WHICH THEY HAVE NEITHER UNDERSTOOD NOR EXPLAINED.

BEING THE FIRST VOLUME OF

AN ORIGINAL SYSTEM OF PHYSIOLOGY,

ADAPTED TO THE ADVANCED STATE OF ANATOMY,

By ALEXANDER WALKER,

AUTHOR OF "PHYSIOGNOMY FOUNDED ON PHYSIOLOGY."

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TO

SIR ANTHONY CARLISLE.

Dear Sir,

When, thirty-five years ago, I met you at the house of our philosophic friend, you dissuaded me from the cultivation of science, and pointed it out as an unprofitable path—the road only to ruin. Our destinies, however, are inevitable; because they result from the character of our minds.

Convinced, that a knowledge of the brain and its functions will be found to be the short and sure remedy for the greatest moral, civil, and political evils, I subsequently worked for years both in an hospital dissecting-room and in my own. And the result of thinking, as well as working, has been as you predicted.

To you, therefore, I inscribe the work which contains such ample proof of your prescience.

When incapacity legislates, and knowledge is taxed, and Babbage and Herschel acknowledge the decay of science, he would be unreasonable indeed who should expect profit from those higher pursuits of philosophy which, though by far the most prolific both of pleasure and of benefit to mankind, yet must always seem at first unproductive of either. Happily, the true and devoted cultivator of science cares little about fortune.

And let me ask, whether the discoverer of the chemical influence of the voltaic pile, from which, in the hands of the mere showmen of science, such a train of splendid results have sprung, and, which is more to the purpose, whether the philosopher who in England has laboured hardest in comparative anatomy, and thought most boldly in physiology, owes his better fortunes to his achievements in science? Yet these achievements were yours; and your pursuits are still the same!

May you live and continue them till the generation rises, which is capable of appreciating all you have done.

ALEXANDER WALKER.

TO THE READER.

The reader who wishes to peruse *the portion of this system which has been borrowed, inverted, and blundered about, by Bell, Magendie, &c.* will find it in Chapter II. Part II., commencing at page 279, where it constitutes *a small portion of more extended and systematic views.*

The reader who wishes to peruse the portion which describes THE ORGANS OF THOSE GREAT MENTAL FACULTIES which are universally acknowledged, and which displays organizations corresponding with whatever we know of these faculties, will find it in Chapter IV. Part II., commencing at page 446.

CONTENTS.

The whole of the preceding chapters, it is hoped, give a far more complete view of the Structure and Functions of the Nervous System and of the Brain in particular, than is elsewhere to be found.

ERRATUM.

Page 380, line 22. (*in some copies*) *for* moving, *read* hearing.

LIST

OF SOME OF THE TERMS EMPLOYED,

WITH THEIR SYNONYMS.

In using technical terms derived from a foreign language, it appears to the writer that they generally receive a mental and silent translation, and that they accordingly impede the rapidity of thought. It is still worse when these terms express neither structure nor function; for instead of facilitating, they then obstruct, the acquirement of knowledge. Whoever, therefore, tries the experiment of using, instead of such terms, others which are both vernacular and expressive, will soon perceive its advantage.

Here, accordingly, instead of terms from the Latin or Greek, the author has preferred English ones, whenever he could find them preferable, or even equally good. He has done this even in quotations, when meanings alone, not terms, were of consequence. He has retained old names, however, in quotations made in proof of prior discovery, where any change of term might be disputed.

Acephalous, headless.
Anterior peduncles of the cerebel, processus cerebelli ad testes.
Anterior striated bodies, corpora striata.
Bend, hypocampus, hippocampus, cornu ammonis.
Brain, cerebrum, sensorium commune.
Brown, cineritious, or cortical, matter of the nervous system.
Bundles, fasciculi.
Cerebel, cerebellum, smaller brain.

Cerebellic, belonging to the cerebel.
Cerebral, belonging to the brain.
Cerebral peduncles, crura cerebri.
Cuticle, scarf-skin.
Drum, tympanum.
Encephalic, contained in or belonging to the head.
Encephalon, the brain, cerebel, and oblong process.
Fatty, adipose.
Four tubercles, tubercula quadrigemina or bigemina, nates and testes.
Ganglion, nervous enlargement—ganglia, its plural.
Ganglionic, belonging to ganglia.
Great commissure, superior commissure, corpus callosum.
Half cone, scala—half cones, scalæ.
Mucous net, rete mucosum.
Neurilema, membranous investment of nerves.
Oblong process, medulla oblongata.
Ossicles, ossicula, little bones.
Oval hole, fenestra ovalis.
Perforated plate, lamina cribrosa.
Posterior striated bodies, thalami nervorum opticorum, optic chambers.
Pyramids, pyramidal bodies, corpora pyramidalia.
Retina, expansion of the optic nerve.
Ring of the cerebel, tuber annulare, pons varolii.
Round hole, fenestra rotunda.
Sinuses, cavities.
Spinal cord, spinal marrow, medulla spinalis.
Spiral cone, cochlea.
True skin, corium.
Viscera, organs contained in the greater cavities.
White, medullary, matter of the nervous system.
Will, volition.
Zone, zona mollis.

ADVERTISEMENT.

THIS Advertisement and the following Preface are not perhaps such as are usually prefixed to books. The subject of the work seemed to require something different; and the reader, it is trusted, will not be disappointed in them.

The Advertisement, the paragraphs on the kinds of evidence in physiology excepted, may be perused by any reader. The Preface requires of the unscientific reader, a previous perusal of the body of the work.

With the view, however, of adapting the work as far as possible to the general reader, as well as to the professional student, the author, wherever he could, has avoided mere technicalities, and those statements which suppose things to be known which are unknown, while he has sought to render minutiæ impressive and complexities simple, by explaining the important and interesting functions in which they are associated.

Of all the objects of knowledge, the most important and interesting are certainly those

here considered—the functions of man, and especially those of his nervous or mental system. It is indeed only in relation to man and his mind, that aught besides can possibly have even its subordinate interest. And until this most important branch of physiology is thoroughly reformed, the very bases of moral and political science will be unfixed.

Lord Bacon has said, "that part of inquiry is most necessary which considereth of the seats and domiciles which the several faculties of the mind do take and occupate in the organs of the body; which knowledge has been attempted, and is controverted, and deserveth to be much better inquired." And a recent professional writer observes, that "there is no subject in the vast range of medical science, which carries with it so much interest, as that of the brain and nervous system; nor is there one which has so completely baffled the genius of the most celebrated Physiologists."

Such indeed has been the apparent difficulty of this enquiry, that some have pronounced its objects impossible of attainment. But this at once exhibits miserable incapacity, and involves a gross absurdity:—first, incapacity, because it has always been the practice of weak men to assert the impossibility of discovering those operations of nature which they could not explain, and because in truth we find, that human genius and

industry are every day rendering plain some of those very operations of which such persons had previously asserted the inexplicability; and secondly, absurdity, because the very assertion that these operations are inexplicable, presumes upon a knowledge of their nature which is at utter variance with the assertion. To know that any thing is inexplicable, the cause of inexplicability, the magnitude of the obstacle to this knowledge, must be known:—but the magnitude of the obstacle is of course altogether *relative* to the object of which it impedes our knowledge: —he, therefore, who knows the magnitude of this obstacle, must also know the object in relation to which alone the obstacle exists:—he accordingly, in making such assertion, absurdly declares that he knows that of which he asserts the knowledge to be impossible. It cannot, therefore, be shown, that there exists any insurmountable obstacle to knowledge.

What, then, is the rational method of prosecuting the most easy or most difficult physiological enquiry?—The writer unhesitating answers: 1st, accurately to ascertain structure, and to observe healthy phenomena; and, 2ndly, to recur to comparative anatomy and physiology, in which the beautiful dissections and the beneficent experiments of nature may be found.

To collect such facts is the *first* duty of the

enquirer; and in doing so, the utmost accuracy is the principal requisite. In this work, the author accordingly states no fact, for which, if at all uncommon, he does not quote the authority of Reil, Tiedemann, the Wenzels, &c., or which he has not himself observed in repeated dissections, which are here described, and which every one may repeat.

But though facts are the first object in science, they are by no means the only object, or even the principal one: they are indeed valuable, only for the conclusions to which they lead and the purposes to which they may be applied. Nothing, therefore, can be more ridiculous than the language of a late unjustly celebrated physician, who, when asked by a pupil for the reason of some phenomenon, exclaimed, "Facts, facts, facts, Sir; I never reason."—Mindless animal! He renounced the highest prerogative of humanity.

Just such is the conduct of him who affects to undervalue theory; for theory is a rational assignment of causes. Whoever has fingers or eyes can feel or see facts; but be his art in rising in the world what it may, he may have a brain little capable of reasoning, or have been too idle to improve it. An ignorant and cunning knave of this kind may always be known by his affecting to undervalue theory.

That theory is a rational assignment of causes, such a man carefully conceals; and as, luckily

for him, its meaning is not always understood, he contrives to give it the look of error, or almost of crime. When, therefore, a young student, full of zeal and candour, suggests to him a reason, he impudently repels him with an accusation of theorizing—that is, of reasoning! and if impudence succeed not in putting down the young enquirer, he has recourse to helpless cowardice—shrugs up his shoulders—turns to those of the company who are as old and as ignorant as himself—and exclaims, "You know, Mrs. So-and-so, that I am a practical man." And so could any quack or impostor have said.

The man, then, who blames theory is always ignorant, and always a knave—if he be not a dupe.

But while theory, this *second*, but highest, object of science, is the great purpose for which facts are to be collected, it loses its character—it becomes mere hypothesis or supposition, if facts oppose it. In this work, therefore, the author assigns no reason or theory which structure does not suggest, or which one fact known to him opposes.

Let it not, however, be supposed, that even hypothesis is to be despised. Far from it. Hypothesis indeed is supposition: it may be right or wrong. But there can be no true reasoning — no theory without it; for every theory must first be in some degree hypothesis,

—every true explanation must first be conjectural.

No more appropriate illustration of this can be given than in Harvey's discovery of the circulation of the blood.

" I remember," says Mr. Boyle, " that, when I asked our famous Harvey what were the things that induced him to think of a circulation of the blood? he answered me, that when he took notice, that the valves in the veins of so many parts of the body were so placed, that they gave a free passage to the blood towards the heart, but opposed the passage of the venal blood the contrary way; he was incited to *imagine*, that so provident a cause as nature had not placed so many valves without design; and no design seemed more *probable* than that, since the blood could not well, because of the interposing valves, be sent by the veins to the limbs, it should be sent through the arteries, and return through the veins, whose valves did not oppose its course that way."

Here all was, in the first instance, conjecture or hypothesis; and without it, we never could have had the theory of the blood's circulation.

It is only necessary to remember that the generality of hypotheses on any one subject must be wrong; that one only can be right; that that which originates in facts, and affords the most probable solutions, is good; and that that which,

on any important subject, is contradicted by no fact, but corroborated by all that are known to us, is inestimable. In this work, therefore, when the author suggests an hypothesis, he gives it only as a supposition, which new facts may confirm or not; and, with such qualification, he would assuredly be blameable if he did not give it.

The merest hypothesis which the writer will presume to adduce shall always have for its foundation at least some striking analogy.—But this too is a foundation which is not duly appreciated.

The man of *mere* facts affects to deprecate analogy. He is ignorant that, while he may have but one series of facts, or rather facts unconnected and in no series, the analogist must not only have at least two series of facts, and stand above him even on that ground, but must also be his superior on a far higher ground, namely, that he knows not only facts, but the relations which subsist between them—the very next step to the discovery of the highest truth, and one without which, in many instances, it cannot be reached.

Thus he knows, for instance, that among the great mental organs, there is a series or sequence in existence or place, by the senses being before, the brain intermediate, and the cerebel* or lesser brain behind,—that, among the great mental functions, there is a series or se-

* An English term sanctioned by the use of Willis, &c.

quence in action or time, by sensation being first, intellect intermediate, and will or volition last,—and, when he sees sequence in existence and place thus associated with sequence in action and time, and *that* in all the animals which possess these organs, he is compelled to conclude that they stand in the relation to each other of cause and effect.

When, in scientific research, no distinction is made between great and little facts—when no enlarged view is taken of structure—when no analogy is dreamt of—when no forethought of function exists—the mind is bewildered amidst the multiplication of trifles, no notion of relative importance is acquired, and no great conclusion can be attained.

When, on the contrary, the greater facts, the largest views of structure, every analogy our knowledge can afford, and every indication of the general course of function, are chiefly thought of, the smaller facts seem almost to arrange themselves, their precise mode of dependence presents itself, and the whole is accurately systematized. There is here no foolish prepossession: rational hypothesis opens upon the mind: thus founded, it never seriously errs; and true theory is generally its result.

Merely to collect facts is an easy and mindless task, that any common being can perform: it requires eyes and hands, and almost dispenses

with a brain: it is the work of a toiling wretch who, like the miser, is incapable of using what he possesses. Mere facts lie all around even the savage; but he knows not what he sees; and such, precisely such, is the case with the mere learners of the names of things, the collectors of little facts, the undiscriminating triflers, who think they are cultivating the sciences.

To collect facts, however, discerning great from little objects, to arrange them in the order of their relations and dependence—we should say, to permit them to arrange themselves, to discover the system pursued by nature, and spread through all things, to render a few facts the means of predicating a thousand,—this is the highest achievement of human genius.

It grieves the writer to think how often he has descended to the useless drudgery of *mere* fact-collecting,—how often, previous to lecture, he has, like a child, been induced to refresh his memory with petty facts between which no tie of thought existed, that he might similarly burthen the memory of others,—and all this in obedience to fools affecting to be philosophers by the parrot-like chatter "facts, facts, facts," and knavishly protesting it was not yet *time* to reason, because they were themselves incapable of reasoning. Long experience has now taught him that we know little or nothing of facts till we know something of functions;—that we there-

by, indeed, merely see objects, without knowing what we see!

In the cultivation of science, in short—without facts, we are idle dreamers; without reasoning, we are trifling fools, and to the folly we add knavery, when we pretend that it is not yet time to reason, and throw on nature, or on science, the fault of our own incapacity. Facts and reasoning must go on together, or there is no real progress made. Their separate result is a chemical chaos, or a metaphysical phantasy.

To theorise, or to hypothesize in science, with certain advantage, it is necessary to know the kind of evidence of which its branches admit. It does not appear that this matter is well understood. How, otherwise, could physiology be in its present state, as regards experiment?

The kind of evidence most extensively applicable in science is that of observation. But that method requires, that numerous facts, enlarged views, and powerful reasoning faculties, should be employed. If so conducted, indeed, its results are the most admirable that the mind can contemplate.

The method of experiment is far more limited. It can be employed *only* upon matter that is under our hands. It can, moreover, be employed *safely* upon masses chiefly, and these inanimate.

When experiment is employed upon the atoms or molecules, instead of the masses, of bodies,

the circumstance of their being minute and unseen, and that of their combinations being little known, increases, of course, the chance of obscure result and unsatisfactory conclusion. If, for instance, as is often the case in chemistry, the intimate nature even of the liquid or fluid agent employed be imperfectly known, or it belong to those which must be deemed simple only because they are undecomposed, there is every probability of such experiment only encreasing that chaos of chemistry, which such modes of procedure have already so extensively created.

If experiment be employed not only on molecules, but these animated, or in the act of performing connected and complicated functions, it is worthless. If, for instance, as in physiology, and especially in the physiology of the nervous system, we have to deal not only with minute structure, which the very institution of experiment supposes to be but partially known,—but also with living functions of which we are utterly ignorant,—and these functions likewise complicated with the influence of numerous connected parts,—of all which, moreover, the functions are equally unknown,—the performance of experiment is the act of a person who has not the slightest notion of the use and application of experiment, and it becomes the mere play of a driveller or an idiot.—Of this, the reader will have a striking illustration in the sequel.

The kind of evidence, however, of which physiology admits, is various. The lever-like actions of the locomotive system may be the subject of demonstration. The tubular actions of the vital system may be so in some cases, but cannot in others. The minuter actions of the mental system are altogether insusceptible of it.

In mental physiology, evidence is afforded, either — 1st, by the discovery of phenomena which we see externally, or are conscious of internally, as corresponding with structure previously known to us;—or, 2ndly, by the discovery of structures perfectly adapted to the production of phenomena previously known to us; —or, 3dly, by the discovery of conjunction between structures and functions both previously known, but never previously conjoined by us; — all of these being corroborated by comparative anatomy and physiology. Perhaps the majority of physiological discoveries in the nervous system are more or less of the latter description.

When this correspondence, adaptation or conjunction is obvious and striking, — when, at the same time, contiguous structures and functions are so clear, that the chance of mistake arising from involvement is removed, — and when every connected phenomenon is thus explained, the evidence amounts to proof. If otherwise, it may be a greater or less probability.

Thus, in illustration of the first kind of dis-

covery,—as the same nerve radiating in the zone of the spiral cone or cochlea must receive impressions from vibrations or undulations in each half cone or scala,—as there are two passages for these vibrations across the cavity of the drum or tympanum, one by the chain of ossicles which rests on the oval hole or fenestra ovalis, and the other by the column of air which rests on the round hole or fenestra rotunda,—as, on this account, they must arrive at the half cones in different times,—and as these preceding and succeeding vibrations must, at the same moment, impress the same nerves in the zone; for these and other reasons which need not be enumerated in a mere illustration, the writer, in this case, concluded from structure, that the spiral cone was the organ by which animals connect and judge of the agreement or disagreement of such vibrations.

In this case, the writer was previously aware, that there were concords and discords in sound; but he did not foresee that sounds were thus connected; and it was the structure which finally led him to the conclusion.

In illustration of the second kind of discovery,—as it is proved that the optic image is inverted on the retina,—as by some means it is evidently reverted to the brain,—as these means should be there found, &c. &c. &c.—the writer, in this case, concluded from function, that the crossing and horizontal curve of the

optic nerves reverted the image horizontally; and that their vertical curve around the peduncles of the brain reverted it vertically.

In this case, the writer was previously aware that there existed a crossing and curve of the optic nerve, but he was long deceived by the assertion as to many cerebral parts crossing, and it was after long seeking for the mechanism by which reversion could be effected, that he found it was all the while under his eyes.

In illustration of the third kind of discovery: —

As, on one hand, the anterior roots of the spinal nerves join the anterior columns of the spinal cord, and these run up and expand into the brain, which acquires superadded parts and a general increase with the increase of perceptive and intellectual powers, and appears therefore to be their organ, — as sensation must precede not only motion but perception and intellect, in conformity with the great truth, "nihil in intellectu quod non prius in sensu est,"—as in perfect conformity with this, the anterior columns of the spinal cord, and the anterior parts of the brain, which are their continuation from the pyramids to the extreme radiations of the fibrous cone, are those first completed in the fœtus, — and as, consequently, any nerves from exterior parts, as well as the cerebral columns, or those which conduct these nerves to the brain, must participate in or

contribute to its functions; for these and other reasons, which need not be enumerated in a mere illustration, the writer concluded, that the anterior roots of the spinal nerves were those of sensation.

As, on the other hand, the posterior roots of the spinal nerves join the posterior columns of the spinal cord, and these are directly connected only with the cerebel, which acquires superadded parts and a general increase with the increase of voluntary and muscular powers, and appears therefore to be their organ, — as voluntary action must be the result of will as that is of previous intellectual processes, — as, in perfect conformity with this, the posterior parts of the brain, the cerebel, and the posterior columns of the spinal cord, which are its continuation, are those last completed in the fœtus,—as, about the period of their completion, the fœtal motions are first felt,—and, as consequently any nerves from the cerebellic columns, or those which descend from the cerebel, must participate in or contribute to its functions; for these and other reasons which need not be enumerated in a mere illustration, the writer concluded that the posterior roots of the spinal nerves were those of volition.

In these cases, even the facts of structure and the successions of function were previously known to the writer; but he had not observed their conjunction.

On the same subject. and in the same method,—as there are inconscious* as well conscious* sensations, and involuntary as well as voluntary actions, actions which take place in acephalous fœtuses, and in animals which have been either decapitated, or had their spinal cord divided between the point of irritation and the brain,—as these actions evidently depend on the spinal cord and its commissures affording communications between anterior sensitive but inconscious, and posterior motive but involuntary, nerves,—as in consequence of the lateral or olivary bundles avoiding the cerebel or organ of will, both anteriorly and posteriorly while passing within its ring, and being continued downward as the lateral columns of the spinal cord, they appear to be the means of these involuntary actions,—and as there are only two roots to each nerve arising from the spinal cord; for these and other reasons which need not be enumerated in a mere illustration, the writer concluded that, in the functions thus performed, the inconscious was included in the same root with the conscious or perceptive nerve, and the involuntary in the same root with the voluntary nerve.

All this appeared confirmed to the writer by long continued dissections, by careful observa-

* These epithets are used to avoid the circumlocution, "sensations of which we are conscious," &c.

tion, and by the strictest processes of reasoning which he was capable of instituting, and which shall, in the sequel, be laid before the reader. He saw not the slightest need of experiments on living animals to determine this; he hated to perpetrate them; but, being told it was necessary to public opinion, he consented to institute one; and, determined it should be the last as well as the first, he reasoned as follows:—

As, in the higher mental processes, conscious sensation or perception precedes voluntary motion,—as, in lower ones, inconscious sensation or irritation precedes involuntary motion,—as, for instance, irritation of the sole of the foot causes an animal to retract its limb even after the spinal cord has been divided superiorly,—as the motion thus caused is caused through nerves of sensation distributed to the skin,—as this is conformable to the law that without sensation, conscious, or inconscious, there is no motion in animals,—the writer concluded that motion would ensue on irritating those spinal roots which he had previous reason to believe were those of sensation—those roots in which, if he were right, must terminate the very nerves the irritation of which in the sole of the foot had already caused the motion of the limb—those anterior roots, in short, which he was well satisfied were those of sensation; and he thought it probable that he should not, by irritating the posterior roots, pro-

duce voluntary motion, because, although irritation may simulate touch, he knew not how to simulate more mysterious will in a nerve which had already passed through its organ, the cerebel, nor knew he how to simulate the equally mysterious involuntary impulse in nerves which had already passed through its organ in the spinal cord &c. ;—and still further did he despair of producing motion by any direct action upon the posterior roots, when he observed their ganglia, and recollected that although nearly all the motions of the thoracic and abdominal viscera depend on ganglionic nerves, yet no irritation of them affects that motion. On opening the spinal canal of a frog, accordingly, and performing the only operation on a living animal which he ever has performed, or ever will perform, he found that, in perfect conformity with previous reasoning, irritation of the anterior roots caused motion, and irritation of the posterior roots caused little or none.

It will be seen that, in utter neglect of all reasoning, a totally opposite conclusion has been drawn from such experiments ;—that men calling themselves physiologists have asserted, that, because the irritation of *cutaneous nerves*, by producing motion, *proves them to be* sensitive ones, therefore the irritation of *anterior spinal nerves*, by producing motion, *proves them not to be* sensitive ones ;—or (if this form please them better)

that because the irritation of *cutaneous nerves*, by *producing motion*, proves them to be sensitive ones, therefore the irritation of *posterior spinal nerves*, by *producing no motion*, proves them to be sensitive ones;—or that because the irritation of *ganglionic nerves* in the *chest*, by causing no encrease of motion, *does not disprove* their being motive nerves, for on them, the motions of the viscera indisputably depend, therefore the irritation of *ganglionic nerves*, in the *spine*, by causing no motion, *does disprove* their being motive nerves; —that, in short, the strictest analogy and the closest reasoning is useless in physiology, and that ignorant and reckless experiment, especially when it is unexplained or explained so as to contradict all living and healthy phenomena, is the test of perfect adaptation for physiological research.

Here, then, experiment was obviously useless to the writer; and when it was made by others, it was not understood by them (see their printed works!) until he explained it to them, as he now does, and will further do in the following Preface. —So much, then, for the vast superiority of dissection, observation of function, and recourse to comparative anatomy and physiology.

Sometimes the discovery of the function of intermediate parts is made out by the knowledge of those between which they are placed.

Thus, observing that the anterior nerves and

columns of the spinal cord evince sensation (not by susceptibility of pain, for that, as will be shown, has nothing to do with any specific sense), but by being the easiest means of exciting voluntary or involuntary action, and that consequently they are the ascending masses; —observing also that the posterior columns and nerves of the spinal cord proceed from the organ of the will, and that consequently they are the descending masses; and further observing, that as, of the fundamental parts of the brain, there now remain only those intermediate parts which unite the brain and ascending, with the cerebel and descending, masses, namely the posterior striated bodies and anterior peduncles of the cerebel; —all this being the case, the writer concluded, that, by these intermediate parts, the preceding actions were connected, and that, through them, the nervous motion must accordingly be from before backward. And this he found supported not merely by certain analogies of relative magnitude &c., but by structure unravelled in dissection, by successive growth of parts, &c. &c. &c.

The superiority is evident of such modes of proof to the usual mode of conjecture, in which such correspondence, adaptation or conjunction, or such support from united size, structure and growth, is wanting.

Their superiority is also evident to the false

procedure in which, as in phrenology, various complex functions alone being known, these are empirically ascribed to parts like the cerebral convolutions, which have, throughout, the same unvaried or similar structure.

In such a case, the truth of the assignment of various functions can consequently be supported by no correspondence between distinct and peculiar structure and appropriate function, presenting reasons for phenomena, but only by an unreasoned and empirically asserted correspondence of size, or by the vague circumstance of coexistence in the same being.

Now, it is precisely this empirical method, employed where both the external appearances and the supposed faculties are numerous, that has, in all ages, been a source of delusion,—as in palmistry, the art of telling fortunes by moles, &c.

Thus, then, is seen the nature and superiority of that evidence which can alone constitute proof in mental physiology; and if this higher evidence, in which structure and functions evidently correspond and throw light on each other, were rejected, then must the greater half of human science be rejected along with it.

Thus much of evidence, indeed, it is not always easy to obtain, especially in some deep-seated and somewhat insulated parts of the brain. The analogies are there fewer in number and more

difficult of observation. These, however, it is the province of genius to discover; and he who would extinguish the light even of its suggestions, would reject the first bases of scientific truth, and indefinitely postpone its establishment.

The author has here one remark, personal to himself, to make.—It is now precisely twenty-five years since he first published some of the more important of the doctrines contained in this work. He then discovered that it is just as unfortunate to be a little before, as to be much behind, either in the cultivation of science, or in the progress of public opinion. Such anticipation is gained only by a sacrifice of that fortune in the world, which is never hazarded, and always easily ensured, even by low and common minds. Nay more: he found it productive only of unmitigated moral evils. New truths of a higher order, and of which the connexion is not seen with common and hackneyed doctrines, are scouted by all, and especially sneered at, denied, and abused by the base creatures who have just sense enough to see that there really is something in them, who have just ambition enough to make them hate one who appears to know more than they do, and who have just cunning or skill enough to bias minds yet weaker than their own. To crown suitably such procedure, the doctrines at first denied, are subsequently pilfered, with all

the little art of which such minds are capable. It is the last, perhaps one of the least of consolations, that justice may ultimately be obtained.

Notwithstanding the writer's long-continued dissections of the brain, in a great portion of which his friend and pupil, Mr. John Lizars, practically assisted him—notwithstanding also, that, in almost every instance, he referred to structure laboriously investigated, and clearly described,—it was thought a device of some ingenuity, especially in a subject where comparatively few, it was guessed, would be inclined to follow him—to brand his discoveries with the terms theory, hypothesis, &c.

There was perhaps no remedy for this device, but that which time and events have so effectually presented — namely, that these discoveries, when it was thought they were forgotten, should be laid hold of by others, —altered by the ignorance, or caprice, or cunning, of their adopters,—presented, thus travestied, to learned societies, — received with applause, notwithstanding the blunders thus attached to them, — then quickly claimed by others, who declared that they also had made them at the very moment with the twelve-year-subsequent adopters of them,—speedily spread over Europe, where each claimed some little or recent share in them, or discovered them over again, without, of course, ever having heard of

them before,—and finally become the doctrine of the nervous system inculcated in every physiological work.

It was only further necessary, that every one of the deviations from the original doctrine should be now proved to be egregious blunders committed by men equally ignorant of structure, and incapable of reasoning as to functions. This the writer must say *is* done, even in the following Preface. He will there prove the plagiarisms to which he has been subjected; he will demonstrate the blunders, even from the experiments of the blunderers; he will show the precise and indisputable delusions under which these blunders were committed; he will expose the incapacity for physiological discrimination which marks the reasoning of those who committed them; he will render the abandonment of the false doctrine, and the adoption of the true one indispensable; existing, compared with forthcoming, works shall be his evidence of the change, and there shall be no room for dispute about this; and if, after all this, the writer shall be told that he only, by a sort of intuition, conjectured the true yet complicated doctrine of the nervous system, he shall not object to the higher compliment which this implies.

The disagreeable—the almost disgusting subjects of the preceding remarks are those only of

his Preface.—It will be observed that, of the discoveries presented in the body of the work, those which regard the fundamental parts of the brain, and which are the ground-work of the rest, were published by the author in the years 1808 and 1809,—that he now gives these discoveries in the words then employed by him, referring to published works,—that where the structure as well as the function has exclusively been observed by him, he describes the process by which the same may be seen by any observer,—and that where he quotes descriptions of structure from the works of the profoundest anatomists, it is only to remove all doubt as to his own reasonings respecting functions.

It will especially be observed, that of these physiological doctrines, even the excellent writers thus quoted seem to have had no notion; for the mere structure is often described by them in patches and unconnectedly,—often in an order which is the reverse of that of their functions,—and often one portion of an organ or series of organs is described in functional order, and the other portion in the reverse.

Such proofs of this utter neglect of all physiological relation by the best anatomists are given throughout the work, that it is evident they thereby lost the most enlarged views even of structure itself—and that they may truly be said not to have known what they saw! If this be

thought too severe, let the reader, after perusing this work, recur to any existing system of physiology upon the same subject, and say how, otherwise, such a web of blunders should exist at this moment.

The author has not adverted to any of the innumerable physiological errors which the application of this doctrine exposes, and of which some are to be found nearly in every page of every physiological work, that has a relation to the nervous system. It will interest and amuse the student of physiology to make these applications.

PREFACE,

CONTAINING

SOME ACCOUNT OF THE DISCOVERIES MADE BY THE WRITER AS TO THE NERVOUS SYSTEM, AND SUBSEQUENTLY TREATED OF BY MESSRS. ROLANDO, BELL, MAGENDIE, MAYO, BELLINGERI, FLOURENS, DESMOULINS, SCHOEPF, ETC.

If the study of man be by far the most important, and if, in that study, the most important portion be that which regards the nervous system and the mind, then may some recent discoveries respecting it, be regarded as not the least valuable of modern advances.

The writer having actually originated these discoveries, as, by reference to printed documents, he will here indisputably prove, he feels himself called on to sketch their history as preliminary to physiological doctrines which, in the body of the work, will be better rid of every thing like literary dispute.

DISCOVERY OF THE FUNCTION OF THE CEREBEL, BY THE WRITER, IN 1803.

One of the most important, then, because the most fundamental, of the discoveries alluded to, is that which regards the use of the cerebel or smaller brain, situated under the back part of the greater brain, and above the neck.

As alluded to or explained in early Works.

In "Tables of a Natural System of Medical Science," proposed by the present writer, and printed by Messrs. Oliver and Boyd, of Edinburgh, on the 1st of March, 1808, as appears from the Tables themselves, he first, in a printed work, assigned the function of will or volition to the cerebel; though he had held, and occasionally taught that doctrine ever since the year 1803.

In "Outline of a Natural System of Medical Science," forming his preliminary lectures, dedicated to Dr. Monro, sen., printed at the University press, on the 27th of October, of the same year, and published by Phillips, in London, and by Bryce and Co., at Edinburgh, the same use was, in an accompanying table, assigned to that organ.

In "Archives of Universal Science," Vol. 1, for January, 1809, published at Edinburgh on the 1st of that month, this was repeated.—Thus, for the third time, within the year 1808, was

this function assigned by the writer; for, even as to the last work, it will be allowed, that a volume of nearly 400 pages, published on the 1st day of 1809, must have been sent to press and printed in 1808.

These are facts which admit of no dispute; and no pretender on this subject has yet appeared, who can establish his claim, by a single printed date, so far back as any of these. No one, indeed, so far as the writer knows, pretends to do so, even by founding such claim on the common devices of *unpublished* lectures, pamphlets printed *without any date*, &c. &c.

At this time, the writer had not attained his subsequent ideas of the nervous system: he imagined the nerves to be more especially dependent upon or associated with the cerebel in the function of will or volition; and he treated them as such, both in these works and in his unpublished lectures.

In the second volume of the work last quoted, for April 1809, the writer — now associating the spinal cord with the cerebel in the production of volition, and considering certain nerves (for he now divided them into two kinds, nerves of sensation and nerves of volition) as merely the means of transmitting voluntary impulses — expressed himself thus: —

" As sensation and volition seem exactly op-

posed to each other, so is the face, containing the organs of sense, to the cavity containing the cerebellum. The analogy also attends their situation in animals; for as, in the inferior classes, the face advances, the cerebellum uniformly recedes, and both are generally separated from the cerebrum, either by membranes, or by bony plates.—Man also has the greatest cerebrum, compared with his cerebellum, and has likewise most of intellect, though not most of loco-motion."

In the third volume of the same work, for July 1809, the writer further observed, that—"From the peculiar opposition which subsists between the situation of the face and cerebellum, we are entitled to expect a similar opposition in their functions. As the face, therefore, occupied by the chief organs of sense, is the seat of sensation, so we might expect the cerebellum to be the organ of volition. This supposition receives additional force from the consideration that, as the organs of sense and the cerebellum are the first and the last portions of the nervous system, so sensation and volition are the first and the last of its functions. But this supposition seems confirmed, when we recollect, that the degrees of voluntary power always bear a close analogy to the various magnitudes of the cerebellum."

As further illustrated in the Annals of Philosophy.

This, after the lapse of six years, was repeated, extended, and enforced in Dr. Thomson's "Annals of Philosophy," for July 1815, as follows:*—

"Willis thought the cerebellum was the organ of involuntary power. 'The office of the cerebel,' says he, 'seems to be for the animal spirits to supply some nerves, by which involuntary actions, which are made after a constant manner unknown to us, or whether we will or no, are performed.'†

"Willis was right in assigning to the cerebellum the involuntary motions; but he erred in excluding the voluntary ones."—The writer *now* finds that, in the preceding sentence, he conceded too much to Willis, and that the cerebel has nothing to do with *involuntary* motion, which has its peculiar organs, as will be shown in the sequel.

"Haller says, 'Convulsiones artuum constanter videmus in animalibus supervenisse, quorum cerebellum vulneraveramus.—Et de convulsionibus dictum est, quæ sunt musculorum voluntariorum. Ex cerebello etiam, si ullus, quintus sensui destinatus et voluntario motui

* This is quoted here in an abridged form, because it is necessary to introduce it systematically, and even to extend it in the body of the work.

† On the Brain, Chap. xv.

nervus prodest. Quare, collectis omnibus, videtur cerebellum et a cerebro hactenus parum differre, et graves in utrovis læsiones mortem inferre, leviores in utroque tolerari. Dein cerebrum ad vitalia organa et sentientem vim et moventem mittere, et ad partes mentis arbitrio subjectas cerebellum.' Here, then, it appears that Haller, after proceeding upon an 'it is said,' as to the convulsion of the voluntary muscles,—observing that the fifth pair coming from the cerebellum is, however, destined both to sense and motion,—and thinking that, upon the whole, the cerebellum in so far differs little from the cerebrum,—at last concludes, that the cerebrum seems to send both feeling and moving power to the vital organs, while the cerebel sends both feeling and moving power to the parts which are subject to the will.

"Now, from this I differ, by asserting that the cerebrum sends neither sensation nor motion to any part, but merely receives sensation from the organs of sense; while the cerebellum has not only nothing to do with sensation, as Haller erroneously asserts, but sends motion both to the voluntary and to the involuntary parts;'—this ascription of *involuntary* motion being inaccurate, as already observed.

"I shall now state some of my reasons for asserting, that the organs of sense being those of sensation, and the cerebrum that of mental

operation, the cerebellum is the organ of volition.

"1. There are three distinct intellectual [mental] organs, or classes of intellectual [mental] organs, namely, the organs of sense, the cerebrum, and the cerebellum.

"2. There are three distinct intellectual [mental] functions, or classes of intellectual [mental] functions, namely, sensation, mental operation [intellect], and volition.

"3. Of the organs, those of the senses are the first, the cerebrum intermediate, and the cerebellum the last.

"4. Of the functions, sensation is the first, mental operation [intellect] intermediate, and volition the last.

"5. As, then, the cerebellum is the last of the intellectual [mental] organs, and volition the last of the intellectual [mental] functions, and as, at the same time, there is no organ without function, nor function without organ, it follows, that the cerebellum must be the organ of volition.

"6. In perfect conformity with this truth, the inferior animals, however defective in intellect, possess motion; and, in almost all of them which have any visible nervous system, a cerebellum, the organ of that motion exists.

"7. This truth receives new confirmation

when we observe, that the degrees of voluntary power always bear a close analogy to the various magnitudes of the cerebellum."

Of the preceding extract, and of all the extracts from his previous Papers, which are given in this Preface, the writer begs to observe, that they are not here given as proving any doctrine; for they are divested of the details which serve that purpose, and which would themselves have made a volume: they are merely quoted as establishing priority on the subjects they refer to.

In his work "Physiognomy founded on Physiology," the writer added—"While some physiologists have borrowed the preceding doctrine without acknowledgement, Dr. Fleming, in his Philosophy of Natural History, has subjected it to liberal criticism."

Dr. Fleming's Objections to the Writer's Doctrine as to the use of the Cerebel replied to.

"'According to Mr. Walker,' he says, 'the cerebrum is the organ of sensation [No, not of sensation, but of united sensations or perception], or the centre to which all the impressions are communicated [Certainly, and where they form perception], and in which deliberation is practised, while the cerebellum is the organ of volition. The nerves which terminate in the cerebrum, and the anterior columns of the spinal marrow, convey impressions to the mind; and the nerves which arise from the cerebellum and

the posterior columns of the spinal marrow, execute the purposes of volition.

"'As we descend towards fishes, the cerebrum diminishes so much in size, that its total absence may be inferred in the lower classes. Observation confirms the supposition. It can scarcely be detected in the mollusca, and it is wanting in the annulosa. Now if these opinions with regard to the uses of the cerebrum and its different parts were correct, we ought to find in the animals which are destitute of the organ a total want of the functions which it is destined to perform; for we can scarcely suppose, that any of the other organs of the body can supply its place. But still we find, among insects, for example, not merely sensation and volition, but instincts, propensities, and deliberation which, when they occur in the higher classes, are considered worthy of having peculiar organs set apart for their production.'"

"Now, here, Dr. Fleming has failed to observe that, to animals wanting a cerebrum, I do not deny sensation, for that is the function of the organs of sense! and as to volition, they ought assuredly to possess it, since they possess its organ, as in the next paragraph Dr. Fleming allows!

"'But the cerebellum,' says Dr. Fleming, 'still exists in these mollusca and annulosa; and may therefore, be considered as exercising the functions of sensation and volition. [It is not ne-

cessary it thould exercise the former!] Let us descend, therefore, to the inhabitants of the Co rals or to the Hydræ: in these, neither brain nor nerves can be perceived. Yet they evidently possess both sensation and volition, and as evidently want a cerebrum and cerebellum.'"

"The same oversight is committed here as to sensation! the surface of these animals is evidently their organ of touch. That, however, which in them Dr. Fleming calls volition, is evidently of the most imperfect kind, if it at all deserve the name: without either central portion or nervous connexion, it is certainly, like their sensation, confined to the mere particles composing them. As their sensation cannot become perception, so neither should such motion be denominated volition. They have accordingly little or no locomotive power? To palpable volition, inducing palpable locomotion, a cerebellum appears to be indispensable."—In short, the writer should have said, they are capable only of unconscious sensation, not of perception, and of involuntary, not of voluntary motion, and they therefore as little require a cerebel as a brain.

The earliest work on this subject by any other writer, appears to be Rolando's "Saggio sopra la vera Struttura del Cervello dell'Uomo e degl' Animali, e sopra le Funzioni del Sistema nervoso, Sassari, 1809," in which the author endea-

vours to prove that the cerebel is the *originator* of voluntary motion.

* Expériences sur les fonctions du système nerveux,
Par le Professeur ROLANDO.*

Un chevreau fort agile, sur le crâne duquel j'appliquai le trépan en deux différens points, me donna des résultats beaucoup plus satisfaisans. J'introduisis un stylet par une des ouvertures faites avec le trépan ; je coupai presque tous les filets de substance médullaire qui traversent la portion cendrée, d'où elle prend le nom de corps cannelé ; j'intéressai même le corps calleux et le septum lucidum : cependant l'animal restait sur ses pieds, et marchait en tournant du côté de la partie lésée. Une demi-heure après, je fis une lésion semblable sur l'hémisphère gauche ; mais je coupai les filamens nerveux dont j'ai parlé, beaucoup plus près de leur origine, et vers l'endroit où ils conservent encore le nom de jambes du cerveau. Quoiqu'il fût fait une déperdition de sang considérable, l'animal ne laissa pas de rester ferme et immobile sur ses pieds pendant l'espace d'environ deux heures : il ne faisait de mouvement que lorsqu'un choc violent le forçait à changer de situation ; mais des irritations légères, un bruit assez fort, la présence des alimens, ne lui faisaient pas exécuter le moindre mouvement. Deux heures s'étant écoulées, il commença à faire quelques pas pour s'appuyer contre le mur, ou pour se mettre dans un coin ; et il passa ainsi deux ou trois heures dans un état d'assoupissement ou d'un sommeil profond, Vers le soir il se coucha et dormit probablement toute la nuit, puisque le lendemain matin il fût retrouvé dans le même poste. Je le tuai trente-six heures après l'expérience, pour voir les parties qui avaient été intéressées.

* The abridgement which is here given is from a French translation, by Rolando himself, of his "Saggio sopra la vera Struttura del Cervello."

Of course, no statement in a work of that date, can divest of priority even the various printed

La même expérience faite sur un petit agneau donna le même résultat. On doit cependant observer que l'immobilité et l'état d'assoupissement sont moins surprenans ici que chez le chevreau, qui est naturellement plus vif et plus agile.

De semblables expériences furent répétées et variées de mille manières sur un très-grand nombre d'autres animaux, tels que chèvres, moutons, cochons d'Inde, etc., principalement dans le but de voir les phénomenès résultans de la lésion des tubercules bijumeaux, des couches optiques, du corps calleux, de la voûte et de ses appendices. Les résultats furent que, toutes les fois qu'un grand nombre de fibres qui traversent les corps cannelés étaient coupées ou déchirées, que le corps calleux ou la voûte était intéressée, il s'ensuivait un état de léthargie et d'assoupissement, et d'autres fois quelques symptômes fugitifs de catalepsie.

Ayant fait deux ouvertures sur les os pariétaux d'un coq d'une vigueur et d'une activité extraordinaire, j'emportai de la même manière une grande quantité de la substance dont sont formés les hémisphères; je déchirai en outre avec le même instrument non seulement la susdite expansion médullaire, mais encore celle qui occupe la base des hémisphères. Je pratiquai cette opération en trois temps, laisant un intervalle d'une demi-heure de l'un à l'autre de ces temps. A mesure que j'attaquais plus profondément les parties dont je viens de parler, l'animal devenait stupide et restait plus calme. A la fin il s'assoupit, se coucha par terre pendant quelque temps: une heure après il se releva, restant sur ses pieds immobile comme un statue; et il n'y avait ni bruit, ni alimens, ni eau, ni piqûres, qui pussent lui faire faire le plus petit mouvement; ce n'était que par un choc violent, comme un coup de pied, par exemple, qu'on lui faisait changer de situation, et qu'on lui faisait faire quelques pas.

statements above alluded to as published by the writer in 1808—the first so early as March in

J'ai répété cette expérience sur des poulets, des faucons, et des canards, et presque toujours avec le même succès. Les mêmes lésions faites sur un gros corbeau d'une force et d'une finesse singulière sont d'un grand poids en faveur de mon opinion. Il demeura immobile comme le coq; et quoiqu'il se tînt sur ses pieds, il n'en resta pas moins assoupi, tellement qu'il n'ouvrait les yeux qu'à un bruit très fort, et il levait la tête ou la couchait sous son aile, comme il avait coutume de fair en dormant réellement. Aucun objet externe ne pouvait l'émouvoir; il ne se mettait plus en colère à la vue d'un chien ou d'une poule d'eau, ses plus mortels ennemis, et qu'il poursuivait auparavant avec un singulière adresse.

Depuis long-temps j'avais connaissance des expériences du célèbre Fontana, d'oû il résultait qu'en enlevant l'encéphale chez une tortue, celle-ci vivait encore près de six mois, continuant de manger et de marcher comme auparavant. En vain j'avais répété cette expérience : toutes les fois que j'emportai entièrement la masse cérébrale jusque derrière le cervelet, l'animal mourait aussi subitement que ceux à qui l'on coupait la tête.

Voyant que toutes ces expériences étaient infructueuses, je tâchai de les varier, et dans cet intention j'emportait seulement les deux hémisphères du cerveau d'une torιue, laissant les autres parties intactes. Elle vécut pendant très long-temps, ainsi que plusieurs autres opérées de la même manière. Après cette ablation des hémisphères du cerveau, ces animaux devenaient plus stupides; ils ne perdaient pas, il est vrai, la faculté de se mouvoir, mais ils ne le faisaient que rarement et lorsqu'ils étaient fortement irrités. J'emportai les couches optiques chez quelques autres; le résultat fût qu'ils paraissaient seulement un peu plus stupides.

in that year, and, as is evident from the preceding quotations, unremittingly worked upon during the following year.

Je coupai et j'enlevai les deux hémisphères du cerveau sur une très-grosse tortue de mer, chez laquelle cette opération offre plus de difficulté, à cause des grandes masses musculaires dont elle a les os du crâne enveloppés. L'ayant ensuite remise à l'eau, elle nagea pendant quelque temps; puis elle alla au fond, où elle restait tranquille et immobile pendant des heures entières, se tournant seulement quelques fois, tantôt d'un côté, tantôt de l'autre. Cependant quand on la soulevait avec la corde à laquelle elle était attachée, elle nageait un peu, et se laissa ensuite aller de nouveau au fond de l'eau.

J'enlevai les deux hémisphères du cerveau chez le squalus catulus, L.; et l'ayant remis dans l'eau, il s'enfuit avec la plus grande prestesse, quoiqu'il eût le ventricule percé du hameçon avec lequel il avait été pris; il se cacha derrière une pierre, où il restait immobile, à moins qu'il ne fût agacé.

La structure du cervelet, les découvertes importantes faites par le professeur de Padoue sur le grand nombre de feuillets dont il est composé, firent naître en moi plusieurs soupçons sur le véritable usage de cet organe. Je crus qu'il était destiné à la locomotion; et pour confirmer cette opinion, voici les expériences que j'entrepris de faire sur le cervelet.

Il est très-difficile de pénétrer dans le cervelet des quadrupèdes sans les priver tout à coup de la vie; et l'animal qui m'a paru le plus propre à ce genre d'expériences, c'est encore le chevreau.

Une ouverture fait avec le trépan, je coupai en différens sens avec un stylet tranchant le cervelet d'un de ces animaux; après quoi il ne put plus se soutenir sur les jambes, comme s'il avait été paralytique. Il vécut vingt-quatre heures en cet état, et mourut dans les convulsions.

As to the pretence of Flourens, that his papers, printed twelve or thirteen years even after

Je manquerais à la brièveté que j'ai dû m'imposer, si je voulais rapporter minutieusement les expériences que j'ai multipliées de différentes manières sur le cervelet d'un grand nombre de quadrupèdes ; je me bornerai pour le moment à dire que j'ai constamment observé, que la diminution des mouvemens était en raison directe de la lésion du cervelet. C'est pourquoi l'animal était tantôt entièrement paralytique, tantôt d'un côté seulement ; d'autres fois les extrémités antérieures et postérieures seules restaient sans mouvement, suivant que cet organe était détruit en tout ou en partie.

Je trépannai plusieur espèces d'oiseaux sur le point correspondant tantôt à la partie latérale, tantôt à la partie supérieure du cervelet ; et le mouvement des muscles soumis à la faculté locomotrice manqua toujours en raison de la lésion qui avait été faite.

On doit observer que, dans ces altérations du cervelet, l'animal ne devient jamais stupide et assoupi ; il tient les yeux ouverts, regard tous les objects, mais c'est en vain qu'il essaie d'exécuter le moindre mouvement au moyen des muscles qui dépendent de la faculté locomotrice. Il faut convenir néanmoins qu'il agite quelquefois les ailes, et qu'il fait aussi mouvoir les extrémités inférieures ; mais ces mouvemens semblent être l'effet de la seule mobilité dont jouit encore la fibre musculaire, ou bien ils ont lieu lorsque quelque morceau considérable de cervelet reste intact, de manière qu'il peut encore remplir ses fonctions en partie.

Les expériences que j'ai faites sur les animaux à sang froid ont donné des résultats semblables. Une tortue, dont je séparai le cervelet de la moelle alongée, resta entièrement paralysée, et vécut pendant dix ou douze jours sans faire le plus petit mouvement. Après une semblable opération, une autre tortue vit depuis deux mois, sensible comme à l'ordi-

Rolando's! were written without a knowledge of any previous enquiries having a similar re-

naire aux plus petites offenses et à la plus légère stimulation, mais immobile au point de ne pouvoir s'éloigner en aucune manière du lieu où elle est inquiétée. Je traitai de la même manière un lézard, et avec un égal succès; mais ce qui est surprenant, c'est de voir les mêmes phénomènes arriver sur deux serpens d'une espèce extrêmement agile (coluber natrix). N'ayant pas emporté entièrement l'organe d'où dépend la locomotion, chez le premier qui était le plus petit, il resta paralytique pendant deux ou trois heures, mais il recouvra par la suite sa force première, et s'enfuit. Le second ayant été mieux opéré fût entièrement privé de la faculté de se mouvoir; de temps en temps seulement il était agité par des mouvemens incertains, qui n'étaient point dirigés par l'instinct, mais dépendans de la grande mobilité de la fibre musculaire de ces animaux. Il périt au bout de cinq jours.

Je pratiquai la même opération sur un squalus catulus avec beaucoup plus de facilité, parce que le crâne de ce poisson est cartilagineux, et qu'il peut rester plus longtemps hors de l'eau. Il perdit la faculté de se mouvoir; et l'ayant remis dans l'eau, il ne faisait plus que quelques mouvemens vagues et incertains, et ne pouvait plus se livrer à la natation.

As intimately connected with the preceding, I subjoin the following Note:—

Sur le siége du mouvement et du sentiment dans la moelle épinière.—Par M. Majendie.

Il serait sans doute bien à désirer qu'on pût savoir comment le sentiment et le mouvement se propagent de la moelle dans le cerveau. La disposition anatomique indique que le sentiment doit se diriger plus particulièrement vers le cervelet,

sult, it deserves no notice. He differs from the present writer and Rolando in considering

et le mouvement vers le cerveau : mais l'anatomie ne suffit pas ; il faut que la physiologie et les faits pathologiques viennent confirmer l'indication. Or jusqu'ici ni l'un ni l'autre de ces moyens n'a établi ce que l'anatomie semble montrer d'une manière si évidente. Les lésions du cervelet ne font point perdre la sensibilité. La soustraction des hémisphères n'emporte pas nécessairement la perte du mouvement ; l'assertion contraire, annoncée par M. Rolando, n'est point exacte ; ce médecin me paroît s'être laissé tromper par une circonstance accidentelle. Quand on enlève les hémisphères en totalité, il se fait aussitôt un épanchement sanguin, et il se forme un caillot qui remplit la cavité du crâne, comprime la moelle allongée, et produit l'état d'assoupissement observé par M. Rolando. Mais si on empêche la formation de ce caillot, les symptômes sont tout différens ; les animaux sont dans une agitation continuelle ; ils courent ou volent avec une agilité singulière, à moins qu'ils ne soient trop affaiblis par la perte du sang. Les animaux sur lesquels cette expérience réusit le mieux, sont des petits lapins d'un mois ou six semaines, et de jeunes geais et des pies qui commencent à manger seuls. Il est curieux de les voir spontanément courir, sauter, etc., après la soustraction complète de toutes les parties du cerveau placées un peu au-devant des tubercules optiques.*

Les effets de la soustraction partielle ou totale du cervelet sont bien plus difficiles à observer, à raison de l'hémorragie considérable qui accompagne toujours la blessure de cet organe, des épanchemens qui en sont la suite inévitable, et

* Les chats nouveau nés n'ont que des mouvements incertains et généralement assez lents : ces animaux tournent sur eux-mêmes en divers sens. La soustraction des hémisphères leur donne ordinairement la faculté de marcher en avant avec une agilité et une activité singulière.

the cerebel as the *regulator* of voluntary motion.*

Having thus shown, that, in this, one of the most fundamental and important of the late discoveries in the nervous system, the writer was not only at work on it during the same year with Rolando, but had repeatedly published it about twelve months before any work of that gentle-

de la compression de la moelle épinière. Je n'ai pas encore pu assigner à chacun de ces effets la part qu'il prend dans les phénomènes qui se produisent lors des blessures ou des ablations du cervelet ; mais il est pourtant facile de constater que des lésions profondes du cervelet et des ablations totales ne font pas perdre la sensibilité.

* The writer has been informed, that Swedenborg declared, that God, in a vision, had revealed to him, or that he had had a *light* showing him, that, in the cerebel, resided what he called the sensus voluntare, &c. &c. But, potent as is faith in religion, it is worthless in philosophy. There, reason of some kind or other is essential, even to the slightest degree of consideration. Swedenborg's light has, therefore, been exactly what Butler called all inward light — a dark lanthorn which lighted only himself. It could not, therefore, but be disregarded by every body else — as the history of discovery shows it to have been. If, indeed, wild assertion, unsupported even by the slightest attempt at, or shadow of, proof, were to be regarded as anticipation of discovery founded on facts, — then perhaps there never was one discovery which was not first made in Bedlam ; for, amidst innumerable myriads of absurdities, every truth, known or unknown, has there perhaps been uttered again and again, without receiving, or deserving, more attention than the absurdities themselves.

man's appeared, the writer's absolute priority in the discovery of the function of this important organ, must be evident, and he may now proceed to the history of the

DISCOVERY OF THE NERVES AS FORMING TWO CLASSES, NAMELY, THOSE OF SENSATION AND THOSE OF VOLITION, &c. &c. &c. BY THE WRITER, IN 1809.

We are told that Galen divided the nerves into nerves of sensation and nerves of motion.— The writer may leave the answer to Sir. C. Bell, who gives it with admirable complacency and satisfaction. — "I should have been *proud,*" he says, "to be able to say, that I had reconciled the *theories* of the ancients with the more *perfect knowledge* of modern anatomists; but I *fear* it is not so." — "Galen supposed motion and sensation to be the properties of the same nerve, but considered motion to be active and sensation passive, and it was possible, he thought, that there might be nervous power sufficient for sensation, though not for motion. Thus he explained how it happened that sensation remained when motion was lost."* This is quite satisfactory.†

* The Nervous System, Introduction, p. 4.

† As giving, however, a more detailed view of this point, I quote the following from a review of Adams' translation of the Medical Works of Paulus Ægineta, in the 3d No., for April, 1834, of the Medical Quarterly Review.

"With equal futility Mr. Adams endeavours to give to

To the distinction, then, of the nerves as forming two classes, namely those of sensation and

Erasistratus, Aretæus, or Galen, all the merit of *the beautiful modern discovery of the distinct functions of the anterior and posterior columns of the spinal marrow.* In his note on apoplexy and paralysis, in the third book, he makes some more explicit remarks on this subject. —

" 'It is impossible to admire too much the brief but comprehensive account of apoplexy and paralysis given by Aretæus. He states decidedly that there is sometimes a loss of motion alone, and sometimes of sensibility; the reason of which he supposes to be that the sensatory and motory nerves are distinct from one another. This is the germ of a theory fully expanded afterwards by Galen, and lately revived by Sir C. Bell, of London, as a new discovery. It appears, indeed, from the anatomical works of Ruffus, that the famous Erasistratus had attempted a similar classification of the nerves. Galen, however, has the merit of fully establishing the truth of the theory; and all subsequent writers on physiology stated it nearly in the same terms that he does, until ancient authority in medicine and its cognate sciences came to be despised, when it was entirely overlooked, until, as we have already mentioned, it was revived by Sir C. Bell.'

" As the writings of Galen are too voluminous for easy reference, and too expensive to be generally accessible, the following sketch of his more prominent views on the subject of the nervous system may not be unacceptable to the reader.

" The nervous system consists of the brain, the spinal marrow, and the nerves.

" The brain, including the cerebrum and cerebellum, is the immediate seat of the mind, and, as such, the primary organ of sensation and motion.

" The brain, is composed of the same substance as the nerves; the anterior portion is the softer, and gives origin to the nerves of sense; the posterior is harder, and gives origin to nerves of motion.

" The spinal marrow is a production from the cerebellum,

those of volition, the writer was, in some measure, led by the fundamental fact just now

which however it exceeds in consistence. It contains just so much nervous matter as is necessary to form about sixty pair of nerves, which are distributed to each part according to its demands for nervous energy.

" Nerves have three uses : to communicate to the organs of sense their respective sentient faculties ; to excite motion in the organs of motion ; and to enable the organs of the body in general to discern what might be injurious to them. (*De Usu Part.* lib. v. c. 9.)

"The nerves of the senses are soft, like the part of the brain from which they are derived ; they all rise from the anterior part, and pursue a straight course to the organs which they supply.

" The motory nerves are hard, arising from the posterior part of the brain, and the whole of the spinal marrow : these pursue a circuitous course to the parts to which they are distributed.

"Although Galen thus recognised a distinction between the sensatory and motory nerves, he conceived that this difference of function arose merely from difference of consistence. His idea appears to have been a mechanical one, — that the soft nerves were more susceptible of impressions, and the hard nerves less impressible, but stronger, and therefore better fitted for action. He had not the smallest notion of any original difference in the nature of the nervous power communicated by the two classes of nerves, nor that the parts of the central mass from which they spring were respectively the depositories of a sensific and a motific principle, distinct in their nature, and dependent on different modifications of the vital power. That he was entirely ignorant of all this, is evident from his maintaining that the hard motory nerves, although comparatively insusceptible

stated as to the cerebel, for he could not see, in it, an organ of volition, without concluding that the nervous cords connecting it with the

of sensation, do nevertheless possess that faculty in a subordinate degree, and sufficiently to produce the general sense of touch: and also that a nerve which originates as one of sensation from the soft part of the brain, may, at some part of its course, become condensed in its texture, and assume the office of a motory nerve. (*De Usu Partium*, c. xiv.)

"The brain, according to Galen, gives origin to seven pair of nerves.

"1. The optic, the largest and softest of the cerebral nerves, rise from the thalami optici, and joining each other, but without decussation, again separate, and perforate the ball of each eye, where they are ultimately distributed to the crystalline lens, then supposed to be the more immediate organ of vision.

"2. The second pair (the third of the modern arrangement,) are smaller, but harder than the first: they rise toward the back part of the brain, and pass to the muscles of the eye-ball, to which they communicate motion.

"3. The third pair (fifth) are very hard; they rise towards the base of the brain, at the junction of the cerebrum and cerebellum. Only two of the branches of this nerve were known to Galen, viz. the superior and inferior maxillary: these are correctly stated to be distributed to the tongue, where they form the organ of taste; to the muscles of the upper jaw, and those of the face; to the gums, and roots of the teeth.

"4. The fourth pair (apparently the first branch of the fifth,) are small, but still harder than the preceding: they rise from the base of the cerebellum, and pass through the same foramina as the third pair. They go to the palate, where they also minister to the sense of taste.

muscles belonged to the same function, and must be totally distinct from those which connect the

"5. The fifth pair, or auditory, are also very hard; they rise a little behind the last, and go to the internal ear.

"6. The sixth pair (par vagum) are still harder, and rise farther back. They supply many branches to the gullet, stomach, and viscera, and each sends back a recurrent nerve to the muscles of the larynx.

"7. The seventh pair (glosso-pharyngeal) are the hardest of all the nerves of the encephalon, and rise from the junction of the spinal marrow with the cerebellum; they accompany the sixth pair for a short distance, and then, separating from them, are distributed to the tongue, which they endow with motion, and to the muscles of the larynx.

"Galen was unacquainted with the olfactory nerves, though he describes the bulbs from which they are given off: he believed that the extremities of the anterior ventricles of the brain formed the organ of smell.

"The ganglionic system of the great sympathetic nerve was unknown to him.

"Such is a slight outline of the nervous system according to Galen. We have avoided the minutiæ, because they are obscure, and for the most part inaccurate.

"The reader will perceive how little reason there is for Mr. Adams's assertion, that Galen anticipated Sir C. Bell's discovery of the sensatory and motory nerves, which consisted not in suggesting the probability that some nerves were distinct for sensation, and others for motion, but in shewing, with reference to the spinal cord, that the anterior columns have exclusively the power of communicating motion, and the posterior that of receiving the impressions of sense. The diversity of function in the sensatory and motory nerves was ascribed by Galen to difference of texture, by Bell to difference of vital property; and, with re-

organs of sense with the cerebrum or greater brain, and which therefore transmit sensations. —Sir Charles Bell, the first perhaps of those who followed him on this subject, had, on the contrary, no such natural guide.

As Explained in Early Works.

In the volume of the Archives of Science for April 1809, the writer made the following statement.—"The division of nerves into those of motion and those of sensation is absurd, because all nerves are nerves of motion: the proper division is into nerves of sensation and nerves of volition, or nerves of impression and nerves of expression.—Now as, in some cases, sensation

gard to the respective origin of those two classes of nerves, Galen *conjectured*, and was wrong, Bell *demonstrated*, and was right.

"Truly Sir Charles and M. Magendie will be sorely aghast; for, after these gentlemen have been contending for some years about the prior right to this discovery, and we in our simplicity have conceived the question to be settled in favour of the former, in walks Galen, ushered by Mr. Adams, and plays the part of the umpire in the fable of the disputed oyster!

"Jesting apart, Galen knew about as much of this matter as Goliah; and we cannot help observing, that modern erudition may be better employed than in attempting to rob contemporary merit of its just honours; and that it is a poor compliment to the ancients to dress them in borrowed robes, when they look so majestic in their own.

exists without volition, and as almost all nerves arise by distinct filaments, I am of opinion, that wherever a part, having both sensation and motion, is supplied from one nervous trunk, that trunk envelopes both a nerve of sensation and one of volition.—This is confirmed by nerves which are at once connected with sensation and volition consisting of fibres, as the generality of nerves do; while nerves of mere sensation without volition are generally of an uniform softer structure, as the optic, auditory, &c.—The only [other] apparent difference between the nerves of sensation and those of volition, is, that their motions take place in different directions. The latter, therefore, may be said to resemble the arteries; the former, the veins."

In the volume of the same work for July 1809, the writer extended this doctrine; and moreover traced the course of nervous action through the cerebrum or brain.

Now, Tiedemann has shown, that the parts of the cerebral system which are the very first to be discovered in the human embryo, are the spinal cord, the oblong process or medulla oblongata, the cerebral peduncles, the anterior striated bodies, the hemispheres, the posterior striated bodies, the four tubercles, and the cerebel, which are, moreover, the longest to be found as we descend among the classes of animals, in which other parts gradually disappear.—These, there-

fore, are the original, fundamental, and most important parts of the brain.

Now, it is remarkable that, though Tiedeman's work was not then published, these were precisely the parts through which, twenty-five years ago, the writer's dissections of the brain, unaided by any hardening process, enabled him to trace the general course of the nervous fibres and nervous action, as will now be proved by quoting the precise words of the paper referred to.

"The course of the actions in the other matter, the medullary [or white], is precisely the same with that of the structure itself, as I have described it. For, it is evident, that two species of action take place through this structure—one obviously advancing from the organs of sense towards the sensorium commune [brain], and another returning from the sensorium commune to actuate the muscles and produce locomotion. Now, it does not accord with the distinctness of natural operations to suppose, that these motions, in opposite directions, take place through one and the same series of particles. It is far more accordant with that distinctness, to suppose that they take place through different series. And this becomes confirmed, when we observe that circuitous course of the medullary fibres of the brain, which in this Paper, I have described, the double columns of the spinal marrow, which have never

hitherto been traced in connexion with that general course, and the double origins, as they are termed, even of the encephalic nerves [those of the head], which I have here pointed out. Nature thus presents to us the double means by which this double operation is effected.

"But it may be questioned, by which nerves, columns, and cerebral masses, the action ascends to the brain, and by which it descends to the muscles. Fortunately, here nature also directs us. Several nerves of mere sensation [the olfactory, &c.] join the anterior masses; hence they must be the ascending: one nerve [at least—the internal oculo-muscular*] of mere motion proceeds from the posterior masses; hence, they must be the descending;—for sensation, as already said, must ascend to, and volition must descend from the sensorium commune [brain]."

"Thus then it seems to be proved, that medullary action commences in the organs of sense; passes, in a general manner, to the spinal marrow, by the anterior fasciculi [bundles] of the spinal nerves, which are, therefore, nerves of sensation, and the connexions of which with the spinal marrow or brain must be termed their spinal or cerebral *terminations*; ascends through the anterior columns of the spinal marrow,

* The writer might have said the general oculo-muscular, the facial, &c. which penetrate and *pass through* the anterior masses.

which are, therefore, its ascending columns; passes forward through the inferior fasciculi of the medulla oblongata [oblong process], and then through the crura cerebri [cerebral peduncles]; extends forward, outward and upward through the corpora striata [anterior striated bodies]; and reaches the hemispheres of the cerebrum itself. This is the course of its ascent to the sensorium commune.

"From the posterior part of the medulla [white matter] of the hemispheres, it returns by the thalami [posterior striated bodies], passing backward, inward and downward; flows backward in the fasciculi under the nates and testes [four tubercles]; backward and upward through the processus cerebelli ad testes or anterior peduncles of cerebellum; and thus reaches the medulla of the cerebellum itself.*

"From the cerebellum,† it descends through the posterior columns of the spinal marrow,

* It is *now* worthy of remark, that other anatomists, in their unconnected and partial tracings of fibres, support the physiological view given in this paragraph, so far as the structure of the parts is concerned. — But this is the subject of the work.

† From that part, I may *now* observe, apparently returning fibres unite to form the posterior peduncles of the cerebel, which become the restiform bodies on the posterior part of the oblong process, and the posterior columns of the spinal marrow.

which are, therefore, its descending columns; and expands through the posterior fasciculi of all the nerves, which are therefore the nerves of volition, and the connexions of which with the spinal marrow or brain must be termed their spinal or cerebellic *origins*. This is the course of its descent from the sensorium commune toward the muscular system."

In the same volume, he observed, "Hence it is that these nerves and almost all the nerves of the body, have filaments of ascending and filaments of descending impression—are at once nerves of sensation and nerves of locomotion."

It is here not a little curious to observe, that the successive growth of these original, fundamental, and most important parts conforms with the course of action here pointed out.

Tiedemann observes, "that the hemispheres in the fœtus, as well as in animals, are developed laterally and from before backward; that they extend successively in the latter of these directions, over the anterior striated bodies, posterior striated bodies, four tubercles, and at length over the cerebel; that these portions of the brain become gradually more elevated, and more convex;" &c.—p. 237.

These doctrines, the writer must observe, were not hypothetically suggested, but were founded on dissection and actual observation,

conducted first at London during some of the first years of the present century, and afterwards at Edinburgh, during the years 1807 and 1808. And, it should be added that, during the two latter years, and in these very dissections, his able assistant was Mr. John Lizars, then the apprentice of Mr. John Bell, subsequently lecturer on anatomy, and now professor of Surgery to the College of Surgeons at Edinburgh.

In a letter now before the writer, dated 10, May, 1834, Professor Lizars accordingly says, "I distinctly recollect, that it was in 1807 that you commenced your dissections of the brain, wherein I assisted you, and I am glad to learn that you have been repeating them." &c.

In another letter, dated 28, May, 1834, Professor Lizars, after again stating 1807 to be the year in which he assisted the writer in his dissections of the brain, adds "You delivered their results in your Lectures on Anatomy and Physiology, and published them in the Volume for July, 1809, of the Archives of Universal Science, [*the volume already quoted in pages* 30, 52, *&c. in proof of indisputable priority on this subject*]. Since then I publicly taught the same in my lectures on Anatomy, until 1830, when I relinquished the teaching of that science, and was appointed Professor of Surgery to the Royal College of Surgeons."

PARTIAL USE MADE OF THE WRITER'S DISCOVERY BY SIR C. BELL IN 1811.

It is evident, that whatever merit belongs to the preceding observations may be classed under one or other of the following heads—1st, the ascription of distinct functions to equally distinct parts, which in the passage previously quoted, Sir C. Bell shows was *not done* by the ancients,—and 2ndly, the precise accuracy of that ascription.

Under such circumstances, it certainly would have been honourable if Sir C. Bell, who followed the writer in the first respect, had said—Though the ancients failed in that respect, yet a modern writer, Mr. Walker, reasoning on dissections and actual observation, did, two years ago, ascribe sensation and volition to distinct spinal nerves and columns—sensation to the anterior, and volition to the posterior.

Sir C. Bell could then have added—I also, two years after Mr. Walker's publication, infer "that the anterior and posterior roots of the spinal nerves have different functions; but I suppose that upon the anterior root both sensation and motion depend, while the posterior root is an unconscious nerve which may control the growth and sympathies of parts."

This last portion within inverted commas—not the fair concession which precedes it—the

writer quotes as nearly as possible from Mr. Mayo's representation of Sir C. Bell's pamphlet which, it is now said, was printed (not published) in 1811.

First date assigned to Sir C. Bell's Pamphlet, and Observations excited by it.

It is not a little curious, however, that Mr. Shaw, in the Medico Chirurgical Transactions, volume xii. part 1, page 149, should expressly have said, "Sir C. Bell's short essay on the Anatomy of the Brain was printed in 1809."— This date was repeated in Papers, Reviews, Pamphlets, &c.; and Sir C. Bell, who must have perused every one of these, was pleased never to correct this date, so far as the writer can discover, until the publication of his work entitled "The Nervous System," in 1830!

The reason of this may afterwards appear.— It certainly had the effect, unnecessarily indeed, of preventing the present writer from advancing his claims at an earlier period.

At the period when this pretension was not withdrawn by Sir C. Bell, the writer was forced to observe, that, in 1808 and 1809, he was in friendly intercourse with Mr. John Bell, the brother of Sir Charles; that the partner of that gentleman, Mr. Allan, author of various surgical works, attended his lectures; that all the apprentices or pupils of Mr. John Bell did the

same; that through these connections, it seemed not improbable, that Sir C. Bell had heard of his doctrine even before the time of its publication; that the result was — Sir C. Bell's pamphlet, without date of month or even of year! which, though printed, was never published!! and which was, therefore, well calculated to be unknown to all from whom he might think it prudent to conceal it!!! while, at the same time, the period of its being printed might at any future time be stated as a ground for claiming the doctrine it meddled with and mutilated!!!! that meanwhile the writer, in friendly intercourse with the brother of Sir C. Bell, in intimacy with his partner, and daily surrounded by his apprentices and pupils, did not only print but publish his work, with the date of year, and even of month attached to it; and that he left this to the reflexion of every manly, candid, and honourable reader.

He was forced further to remark that it might perhaps be said, that, being in some degree favoured with the friendship of Mr. John Bell, that gentleman might as readily have mentioned to the writer this doctrine as a discovery of his brother's, as the writer might have mentioned it to him as one of his own; that the statement, however, of two or three circumstances would not only clear up this point, but lead to some other conclusions; that—1st, The writer, amidst

Sir C. Bell's relatives and friends, *openly published* the discovery as his own, early in April 1809; while Sir C. Bell (as he says) *privately printed* a pamphlet having some relation to the subject, but never published it, some time in the same year; that—2dly, The writer claimed nothing in common with Sir C. Bell's pamphlet; he had from the first asserted a doctrine in every respect different, to which he had invariably adhered; while Sir C. Bell had shown his real want of philosophical data by shifting his ground, and his followers were more or less approximating the original doctrines of the present writer; that—3rdly, Sir C. Bell's pamphlet did not contain either the facts or the doctrine in question, but only felt its way by cautiously venturing some remarks on the anterior nerves; and that —4thly, It was only because his subsequent procedure, ten years afterwards, namely, in 1821 or later, in pretending to have *thus* originated another doctrine, amounting, even then, only to the ascribing of distinct functions to distinct parts, but ascribing them untruly, and *that* twelve years after the present writer had not only ascribed distinct functions to distinct parts, but ascribed them truly,—it was because this absurd pretence showed his unfair intentions, that the pamphlet was at all alluded to by the present writer, in order to expose the scheme to merited reprobation.

Date now assigned to Sir C. Bell's Pamphlet, and Observations on its contents.

In his work, however, entitled "The Nervous System," published in 1830, Sir C. Bell, formally and repeatedly abandons all claim to that date. In page 14, he says—"I printed a little work in 1811, which I entitled 'An Idea of a New Anatomy of the Brain, submitted for observation of the Author's Friends,'" And again, page 21, he says—"The 'Idea of a New Anatomy of the Brain,' &c. was published [printed it should be] in 1811."

The writer, therefore, will now proceed to quote, from Sir C. Bell's pamphlet, the passages which give such a view of his doctrine as he presents; and—indistinct and inconclusive as it is, as to the functions of these parts,—and completely contradicted as, in that respect, it has subsequently been by himself,—the reader can easily compare it with the far more extensive doctrine delivered by the writer two years before, and quoted in the preceding pages.

Page 21, he says—"I took this view of the subject. The medulla spinalis has a central division, and also a distinction into anterior and posterior fasciculi, corresponding with the anterior and posterior portions of the brain. Further, we can trace down the crura of the cerebrum into the anterior fasciculus of the spinal marrow, and the crura of the cerebellum into the posterior fasciculus."

Let this miserable nibbling be compared with the 3rd and 5th paragraphs above quoted from the writer's Paper of July 1809, and its little travesty will be obvious.

But Sir C. Bell proceeds—"I thought that here I might have an opportunity of *touching* the cerebellum, as it were, through the posterior portion of the spinal marrow, and the cerebrum by the anterior portion. To this end, I made *experiments!* which, though they were not conclusive, encouraged me in the view I had taken."

This is mere affectation about touching, &c., and nonsense about experiments. They will be found in the sequel to be good for nothing—even according to Sir C. Bell's own confession!

"I found, he proceeds, that injury done to the anterior portion of the spinal marrow, convulsed the animal more certainly than injury done to the posterior portion; but *I found it difficult to make the experiment without injuring both portions!!!*

"Next, considering that the spinal nerves have a double root, and being of opinion that the properties of the nerves are derived from their connexions with the parts of the brain, I thought that I had an opportunity of putting my opinion to the test of experiment," &c.

Let this also, as to double roots, be compared with the preceding extract from the writer's Paper of July 1809, and it will be seen that the whole was before Sir C. Bell; and as to the

further "experiment," Sir C. Bell himself is afterwards compelled to acknowledge its worthlessness.

"On laying bare," proceeds Sir C.Bell, "the roots of the spinal nerves, I found that I could cut across the posterior fasciculus of nerves, which took its origin from the posterior portion of the spinal marrow without convulsing the muscles of the back; but that on touching the anterior fasciculus with the point of the knife, the muscles of the back were immediately convulsed."

Sir C. Bell knew not *why* these muscles were convulsed, as will soon be made evident.

"Such," he proceeds, "were my reasons for concluding that the cerebrum and the cerebellum were parts distinct in function, and that every nerve possessing a double function obtained that by having a double root. I now saw the meaning of the double connexion of the nerves with the spinal marrow," &c.

All this is to give the air of experiment (afterwards granted to be useless, by Sir C. Bell himself) to what the present writer had, two years before, stated from dissection and observation.—It will in the end be seen which was most accurate. Indeed, Sir C. Bell abandons the one! and every anatomist now confirms the other!

As to the functions of these parts:—

Page 26, Sir C. Bell says, "*The nerves proceeding from the crus* CEREBELLI go every where

(in seeming union with those from the Crus Cerebri); they unite the body together, and *controul the actions of the bodily frame*;* and *especially govern the operation of the viscera necessary to the continuance of life.*"

It will in the following work be shown, as it was in the preceding extracts from the writer's Paper of July, 1809, that precisely the reverse is true, and that the *cerebel* has little or no direct connexion with the functions of *life!*

Page 27, he says—"The CEREBRUM I consider as the grand organ by which the mind is united to the body. Into it, all the nerves from the external organs of the senses enter; and *from it all the nerves which are agents of the* WILL *pass out.*"

It will also, in the following work, be shown, as it was in the preceding extracts, that precisely the reverse is true, and that the *cerebrum* has no direct connexion with the *will!*

The following is Mr. Mayo's account of this pamphlet and its contents. "Mr. Bell had made experiments upon the spinal nerves, some account of which had been printed and circulated among his friends, as well as delivered in his Lectures. The following is an extract from

* Page 36, he calls these "the *secret* operations of the *bodily frame.*"—"*The secret operations of the bodily frame,* and the connexions which unite the parts of the body into a system, *are through the cerebellum* and nerves proceeding from it."

this account: 'On laying bare the roots of the spinal nerves,' observes Mr. Bell, 'I found that I could cut across the posterior fasciculus of nerves, which took its origin from the posterior portion of the spinal marrow, without convulsing the muscles of the back; but that on touching the anterior fasciculus with the point of the knife, the muscles of the back were immediately convulsed.' Mr. Bell was carried by these experiments very near to the truth, but he failed at that time to ascertain it: he inferred from his experiments, indeed, that the anterior and posterior roots of the spinal nerves have different functions, but in the nature of their functions he was mistaken. *Upon the anterior root, he supposed both sensation and motion to depend: the posterior root, he considered an unconscious nerve,* which might controul the growth and sympathies of parts. Before Mr. Bell published any other account of the functions of these nerves, Magendie had given to the world the true theory of their uses;"—which, however, he has since modified!

But it is right that the reader should see the statement of M. Magendie himself.

"Avant de terminer cet article, je dois donner quelques éclaircissemens sur la nouveauté des résultats que j'ai annoncés.

"Quand j'ai écrit la note contenue dans le

numéro précédent, je croyais être le premier qui êut songé à couper les racines des nerfs spinaux; mais je fus bientôt détrompé par un petit écrit de M. Schaw, que ce jeune et laborieux médecin eut la complaisance de m'envoyer dès qu'il eut reçu le numéro de mon journal. Il est dit dans cet écrit que M. Ch. Bell avait fait cette section il y a treize ans, et qu'il avait reconnu que la section des racines postérieures n'empêchait pas les mouvemens de continuer. M. Schaw ajoute que M. Ch. Bell avait consigné ce résultat dans une petite brochure imprimée seulement pour ses amis, mais non pour la publication. J'ai aussitôt demandé à M. Schaw qu'il voulût bien m'envoyer, s'il était possible, la brochure de M. Ch. Bell, afin que je lui rendisse toute la justice qui lui serait due. Peu de jours après je l'ai reçue de M. Schaw.

"Cette brochure a pour titre:

"Idea of a New Anatomy of the Brain submitted for the Observations of his Friends by Ch. Bell, F.A.S.E. Elle est très-curieuse en ce qu'on y remarque le germe des récentes découvertes de l'auteur sur le système nerveux. A la page 22 on trouve le passage indiqué par Schaw; je le transcris en entier:

"Next considering that the spinal nerves have a double root, and being of opinion that

the properties of the nerves are derived from their connections with the parts of the brain, I thought that I had an opportunity of putting my opinion to the test of experiment, if different endowments were in the same cord, and held by the same sheath. On laying bare the roots of the spinal nerves, I found that I could cut across the fasciculus of nerves, which took its origin from the posterior portion of the spinal marrow, without convulsing the muscles of the back; but on touching the anterior fasciculus with the point of the knife, the muscles of the back were immediately convulsed.

"On voit par cette citation d'un ouvrage que je ne pouvois connaître, puisqu'il n'a point été publié, que M. Bell, conduit par ses ingenieuses idées sur le système nerveux, a été bien près de découvrir les fonctiones des racines spinales; toutefois le fait que les antérieures sont destinées au mouvement, tandis que les postérieures appartiennent plus particulièrement au sentiment, paraît lui avoir échappé: c'est donc à avoir établi ce fait d'une manière positive que je dois borner mes prétentions."

Such is M. Magendie's statement, from his "Expériences sur les Fonctions des Racines des Nerfs qui naissent de la moelle épinière." And, as Sir C. Bell, in 1811, ascribed both sensation and volition to the anterior roots,

it would appear that M. Magendie preceded him *even in assigning distinct functions to distinct parts.*

As this Paper of M. Magendie was published in 1822, and Mr. Shaw then claimed a precedence of thirteen years for Sir C. Bell, it is evident that Mr. Shaw, as usual, ascribed to the very pamphlet, now acknowledged by Sir C. Bell himself to have been published in 1811, the date of 1809!

Sir C. Bell's thus supposing both sensation and motion to depend on the anterior roots, and that the posterior were unconscious (those to which he now ascribes all sensibility!)—so narrow and erroneous a view as this, is scarcely deserving of notice,—even when compared with the subsequent extension of his own views, which involve the columns of the spinal chord as well as the mere roots of its nerves, and assign a distinct function to each;—and still less is it deserving of notice when compared with the writer's, two years previously published, and involving not only the roots of the nerves of one column, but those of both,—the columns themselves,—the progress of the anterior through the brain,—their return through the cerebel,—their descent to join the posterior,—and their completion of the chain of nervous circulation—a circulation as much more important than that

of the blood, as the intellectual is more important than the vascular system.

The writer may now, by contrasting a few paragraphs, point out

Some other striking Approximations, even in this first trifling work.

In Archives of Science, Vol. II, for April 1809, page 179, the writer briefly but clearly said — "Wherever a part, having both sensation and motion, is supplied from one nervous trunk, that trunk envelopes both a nerve of sensation and one of volition."

Two years afterwards, Sir C. Bell, in page 6 of his pamphlet, says—"The view which I have to present, will . . . do away the difficulty of conceiving how sensation and volition should be the operation of the same nerve at the same moment."

In page 190, the writer says —"As, in the inferior classes, the face advances, the cerebellum uniformly recedes, and both are generally *separated from the cerebrum either by membranes, or by bony plates.*"

Sir C. Bell, in page 18, says —"The cerebrum, the anterior grand division, and the cerebellum, the posterior grand division, have *slight and indirect connexion.*"

The present writer there says —"Man has the greatest cerebrum, compared with his cerebellum, and has likewise *most of intellect, though not most of locomotion.*"

Sir C. Bell, in page 20, says —"In the latter [brutes], the cerebrum is much smaller, having nothing of the relative magnitude and importance which in man it bears to the other parts of the nervous system; signifying that the cerebrum is the *seat of those qualities of mind which distinguish man.*"

The present writer there says—"The inferior animals, however defective in intellect, possess motion; and in almost all of them that have any visible nervous system, a cerebellum, its organ exists."

Sir C. Bell, in page 26, says—"In all animals having a nervous system, the cerebellum is apparent, even though there be no cerebrum."

In each of these pairs of paragraphs, there is a striking resemblance. In the train of thought which the series of each writer presents, the resemblance is more striking still. But the most striking resemblance is in the last paragraph of each, because it involves a new analogy.

If, however, these parallels be striking now, how much more would they have seemed three-and-twenty years ago, when no third person was in the habit of taking such views,—but when, also, the secret production of Sir C. Bell's pamphlet prevented the writer from knowing that even a second person was profiting by his opinions!

INVERSION OF THE WRITER'S DISCOVERY BY SIR C. BELL IN 1821 OR 1822.*

Sir C. Bell afterwards abandoned this doctrine, and precisely inverted the doctrine of the

* On again glancing at Sir C. Bell's Papers to the Royal Society in 1821 and 1822, it appears that the writer should not give him credit for this inversion, till the publication of his "Exposition," prefixed to their republication, in 1824.—It may perhaps be said to have been *indicated* in the Papers of 1821 and 1822, so that it was not difficult for any one to make the additional step.

present writer—making the *anterior* nerves those of *volition*, and the *posterior* those of *sensation*.

It is remarkable, however, that, among other writers, returning more or less to the doctrine of the present writer, which has never varied, Bellingeri asserts, that the roots which take their origin in the *posterior columns* do convey impressions that excite *muscular contraction*, and govern muscles of extension! while Schoepf asserts, that the *posterior* columns and nerves, as well as the anterior, are subservient to *voluntary motion!!* and finally Magendie asserts, that, when the *anterior roots* are irritated, appearances of *sensibility* are caused, and when the *posterior roots* are irritated, *muscular contractions* are in some measure caused!!!—The error which these statements involve shall afterwards be made evident: their approximation to those of the writer is the object of the present notice.

The writer has already stated, that whatever merit belongs to his observations may be classed under one or other of the following heads—1st, priority in the ascription of distinct functions to equally distinct parts,—and 2dly, the precise accuracy of that ascription.

Distance of Time even between the Writer's last Repetition of his Doctrine, and its inversion by Sir C. Bell and others.

Now, as to the first even of these heads, it is still more remarkable than all the author has yet

stated, that, long before Sir C. Bell had followed the writer even in ascribing distinct functions—sensation and volition, to distinct columns and nerves (he appears first to have done so in his Papers to the Royal Society in 1821 and 1822, or rather in the Exposition prefixed to them in 1824), the present writer had repeated his previous doctrines in several Numbers of Dr. Thomson's "Annals of Philosophy," for 1815, in consequence of a dispute on the subject with the late Dr. Leach of the British Museum.—Thus it was not till at least six years after this last repetition of the present writer's doctrine, that Sir C. Bell ventured to follow him even in ascribing distinct functions—sensation and volition, to distinct columns and nerves!

As to Magendie, his experiments were not published till July or August 1822; and as they were then published only in the form of a very short notice, it is presumed that they had been but recently performed. In 1822 or 1823, Magendie thought he found, that no pain was caused by irritating the surface of the spinal cord between the anterior roots of the nerves of each side, but that the muscles supplied by them were thrown into violent contraction; and, on the contrary, that acute pain was caused by irritating the posterior columns of the spine between the posterior roots of the nerves. He does not, however, then say whether or not, in the latter

case, he found any contraction to be caused in the muscles supplied by these nerves; and he has since, at least modified these views.

As to M. Magendie, a few additional words are required. He would appear to have cleverly anticipated Sir C. Bell just before he had concluded, as he would speedily, that sensation and volition belonged to different columns. Even now he seems to contemplate further operations of the same kind: he tells us that he has been "engaged at intervals, in experiments on the use of the different parts of the brain, and will make known the results, as soon as they appear worthy of public notice." It was under a similar provision ("nous nous occupons depuis quelque temps d'expériences directes sur ce point," &c.) that he thought he was snatching something good from Sir C. Bell when he adroitly appropriated and improved his remarks on the spinal nerves, not knowing the precise history of these discoveries. But both M. Magendie and Sir C. Bell must learn that printed dates, where actual publication is proved by ample living evidence, will always constitute the sole test of priority. In this, as in other things, the French too often act *en corsaire*.

Of Mr. Mayo the writer wishes to speak with respect. His conduct in discussion with Sir C. Bell, his elaborate work on Physiology, and his invaluable translation of Reil's papers

on the brain, are titles to the respect of every physiologist. Mr Mayo mentions, in his Anatomical and Physiological Commentaries, that being aware of the composition of the trigeminal nerve at its origin being the same as that of the spinal nerves, and having ascertained that its twigs which pass through the ganglion of Gasserius are destined for sensation only, while those which do not, are intended for exciting muscular motion, he was led to conjecture that the posterior and anterior roots of the spinal nerves were similarly circumstanced; and he adds that he was engaged in experiments to determine the fact, when the publication of Magendie's rendered his unnecessary.*

As to Bellingeri, his inquiries are partly recorded in a distinct work, published in 1823,† and partly announced in a short notice in the Annali Universali di Medicina, for March and July 1824.

These writers, therefore, follow the present one at a still greater interval than Sir C. Bell,

* Anat. and Physiol. Comment. No. II. p. 9 & 10.

† *De Medulla Spinali Nervisque ex ea prodeuntibus Annotationes Anatomico-Physiologicæ.* Auctore Carolo Francisco Bellingeri, Regiæ Scientiarum Academiæ, et Collegii Medici Taurinensis Membro, Imp. et Reg. Scientiarum Literarum, et Artium Academiæ Patavinæ Sodali, Regiæ domus Medico.—Augustæ Taurinorum, ex Typographia Regia. 1823.

so far even as the ascription of distinct functions—sensation and volition, to distinct columns and nerves, is concerned.

Here then, (seeing that the doctrines of Sir C. Bell's first pamphlet amount to nothing, and were abandoned by himself) comes the first of the more important points at present in question—the assignment of distinct functions to distinct parts.

Last Statement of the Writer's Doctrine in 1815.

The writer will first, therefore, give some further view of his own statements in the words of his contest with Dr. Leach in 1815, and will next give those of Sir C. Bell in 1821, or later.

In the principal Paper on this subject which was communicated, under the circumstances alluded to, to Dr. Thomson's "Annals of Philosophy," of which the title was, "Sketch of a General Theory of the Intellectual Functions of Man and Animals, given in reply to Drs. Cross and Leach," and which appeared in the Number for August, 1815, the writer wrote as follows:—

"In reply to my statement, that the anterior of the nervous fasciculi [bundles] which join the spinal marrow are not nerves of sensation, nor the posterior, nerves of volition, Dr. Leach, instead of proving my inaccuracy, places upon record a most astonishing specimen of his own!—Dr. Leach says, 'The two roots of nerves of each

half of the spinal marrow, namely, the anterior and posterior, go to different parts of the body: —the muscles and skin of the back receive their nerves from the posterior roots, whilst the muscles and skin of the abdomen receive theirs from the anterior roots, and yet the face and back parts of the body have sensation and voluntary motion.' Now, certainly if this were but true, my doctrine would be not merely inaccurate, but altogether false; for this would prove, that both roots were at once nerves of sensation and of volition: but, not being true, the case is certainly somewhat altered. Unluckily for Dr. Leach, it is his own statement which is inaccurate. In his 'careful examination of the structure of the spinal mass of nerves,' the Doctor has absolutely mistaken the *branches* for the *roots* of these nerves! It is from the branches that the nerves he alludes to go off; for, however lucky this may be for humanity, since it prevents our moving with only one half the body, and feeling only with the other, it is certainly unfortunate for the Doctor's argument, that neither to skin nor muscles is the slightest twig given from the roots.

"These roots then combine, communicate, and even cross by twigs, in order to form a trunk; and, that the Doctor may not be put to the trouble of another 'careful examination,' if he will only cross the fingers of one of his hands

between those of the other, he will have a tolerable conception of the trunk so formed, remembering, however, that only about half the fibrils of either root do so cross, while the other half, instead of crossing to the opposite branch, runs onward in the branch of the same side. A rather greater number of fibrils, indeed, pass from the posterior root to the anterior branch than from the anterior root to the posterior branch, because the anterior branch, being destined to supply a greater portion of the body, requires to be larger.

"I do not find this decussation described in *any* anatomical book, which I have at hand; but the slightest inspection will demonstrate it. The law of this decussation is maintained even in very inferior animals; for in those which have no vertebræ, and in which the spinal marrow is formed below the œsophagus by the union of the two crura [peduncles] of the cerebellum, though the two fasciculi generally remain distinct throughout the greater part of their length, yet they always unite at different spaces by knots whenever a nerve is given off!

"Thus *each branch* is composed from *both roots:* and it is only from the branches thus *composed*, and by no means from the roots, that the nerves the Doctor speaks of are distributed: hence it is not wonderful that they give *both* sensation and voluntary motion. These *branches*,

however, the Doctor calls 'the *two roots of nerves of each half of the spinal marrow*, namely, the anterior and posterior;' and asserts, as is seen above, that these identical *roots* of *each half* of the spinal marrow, 'go to different parts of the body!' Every anatomist and every anatomical work declares that from the roots no twig proceeds either to skin or muscles; and if it were not obvious that the Doctor had mistaken the branches for the roots, I should be apt to think that in his 'careful examination of the structure of the spinal mass of nerves,' the Doctor had refuted the whole of them.

"I have now to mention, that even some of those anatomists who succeeded Willis conjectured that there were cerebral and cerebellic nerves. They indeed only conjectured this; and they, moreover, erred by distinguishing them into vital and animal. The vital nerves, said they, are chiefly derived from the cerebellum, and the animal from the cerebrum. [*Sir C. Bell's doctrine of* 1811 *was absolutely no more than this!!!*] They have *believed*, says Haller, that several nerves have roots partly from the cerebellum. But Haller objects that the fifth pair [trifacial] arising, as he says, from the cerebellum, is appropriated both to sense and motion. He shows also, that some of those nerves which they believe to have some origin from the cerebellum, have nothing to do with vitality; and he ad-

duces various other objections. Speaking of the possibility of fibrils of different kinds being in the same nerve, Haller also says, "Infinitum ad infinitissimum possis deponere, falli hominem, qui Dei consilia voluerit conjectura expiscari." Even Haller, however, when speaking of the double series of roots of the spinal nerves, involuntarily allows some connection of that kind; for he says, "Quarum anterior altera in eodem cum cerebralibus nervis ordine pergit, posterior medullæ propria est, et demum sub fine quarti ventriculi incipit."

"In proof, however, that the sensitive and motive nerves are perfectly distinct, I can quote for Dr. Leach a much better authority than that of any old author:—

"First, that of reason, which tells us, that as sensation cannot reach the cerebrum without an ascending motion—a motion towards the brain; as the consequent volition cannot affect the muscles without a descending motion—a motion from the brain; and as it is contrary to all analogy that there should be motion in opposite directions in the same tubes of neurilema—for these reasons, there must be a series of nerves appropriated to each.

"Secondly, the authority of anatomy, which shows us that though nerves supplying parts which are contiguous in position but different in nature, often run in one common sheath, yet, on

arriving at the spinal marrow, they split into two roots, as they are termed; that these roots are quite different in form, the anterior being more fibrous, and the posterior more simple and round; that the anterior roots join the anterior columns of the spinal marrow, and the posterior roots the posterior columns; that these columns actually do join the cerebrum and cerebellum respectively," &c.

"The leading heads, then, of this new system of the intellectual functions, are as follows:"—

"1. That the nerves of sensation arise in the organs of sense, and, by means of the anterior fibrils, terminate in the anterior columns of the spinal marrow."

"2. That those nerves of sensation which do not terminate in these columns, pass directly to the cerebrum."

"3. That the anterior columns of the spinal marrow terminate also in the anterior part of the cerebrum."

"4. That these nerves and columns are sensitive or ascending nerves and columns."

"5. That it is in this way that sensation becomes perception, and that are excited in the cerebrum the [various] faculties," &c.

"6. That the cerebral influence passes to the cerebellum by means of the corpora striata posteriora or thalami [posterior striated bodies], the anterior peduncles of the cerebellum," &c.

"7. That the cerebellum is the organ which gives impulse to all muscular motion, voluntary and involuntary."—It should have been, to all voluntary motion.

"8. That the posterior columns of the spinal marrow originate in the cerebellum."

"9. That from the cerebellum arise also several nerves of volition."

"10. That these nerves of volition which do not arise directly from the cerebellum, spring from the posterior columns of the spinal marrow by means of the posterior fibrils."

"11. That those nerves and columns are the motive or descending nerves and columns."

"It appears, then, that there is a species of circulation in the nervous system, of which I have sketched the general course, as curious and admirable as that which exists in the vascular (the centre of the one being the heart, and of the other the head); and that there is scarcely any point of the body which this circle does not involve and rest on, since, from almost every point ascends impression to the cerebrum by a nerve of sensation, the anterior nervous roots, and the anterior columns of the spinal marrow; and to each returns expression from the cerebellum by the posterior columns, the posterior nervous roots, and the nerves of volition."

The following, then, published six years after all this—namely in papers to the Royal Society

in 1821, or later, is the very earliest statement by Sir C. Bell in which even distinct functions are ascribed to distinct parts; and this was afterwards republished under the title of "An Exposition of the Natural System of the Nerves of the Human Body, with a republication of the papers delivered to the Royal Society [in 1821 and 1822] on the Subject of the Nerves." London, &c. 1824.

Inversion of the Writer's Doctrine by Sir C. Bell, at that time.

"The anterior column," says Sir C. Bell, "of each lateral division of the spinal marrow is for motion; the posterior column is for sensation; [The very reverse of these two assertions will be shewn to be true]; and the middle one is for respiration. The two former extend up into the brain, and are dispersed or lost in it; for their functions stand related to the sensorium: but the latter stops short in the medulla oblongata [This last is an anatomical error: Reil has clearly shown the reverse], being in function independent of reason, and capable of its office independent of the brain, or when separated from it."—Exposition, &c. p. 22.

"The spinal nerves are perfectly regular in origin and distribution, and are thirty on each side. Each nerve has two distinct series of roots coming out in packets or fasces, one from

the posterior column, and one from the anterior column, of the spinal marrow."—p. 26.

"The anterior roots of the spinal nerves, and the anterior column of the spinal marrow, being thus shown to have a power over the muscular system [Only an indirect one through sensitive bundles], the next step of the inquiry was distinctly indicated. If I pursue the track of the anterior column of the spinal marrow up into the brain, shall I find the nerves which arise from it to be muscular nerves? An anatomist will at once answer, that only muscular nerves arise in this line."—p. 31.—[He may do so, if he is ignorant enough to be unaware that the general oculo-muscular, facial, &c. pass through the anterior to the posterior bundles.]

"On finding this confirmation of the opinion, that the anterior column of the spinal marrow and the anterior roots of the spinal nerves were for motion, the conclusion presented itself that the posterior column and the posterior roots were for sensibility."—p. 33.—[Yes, but not till 1821, or later; for Sir C. Bell's previous publication asserted that the posterior column and posterior roots merely "controuled the *secret operations* of the *bodily frame*, and especially the operation of the viscera necessary to the continuance of life."]

Now the reader, after perusing the summary in page 80, will observe that this is a mere inversion of the present writer's doctrine, publish-

ed not only six years before in Dr. Thomson's "Annals of Philosophy," but also twelve years before in "Archives of Universal Science."

This inversion leads the writer to consider the second head requiring notice, in these researches, namely, the precise accuracy of the original ascription of functions to these parts by the present writer, or of the thus long subsequent ascription of them by Sir C. Bell.

It is here not a little remarkable that the writers who have followed even Sir C. Bell, have all, in greater or less degree, returned to the original doctrine of the present writer.

Partial return of Sir C. Bell's Followers to the Writer's Doctrine.

"Each root," says Bellingeri, "consists of three sets of filaments: the anterior are derived partly from the anterior column, partly from the lateral column, and partly from the bottom of the anterior lateral grooves; and the posterior roots are derived from the posterior columns, lateral columns, and posterior lateral grooves." —He endeavours to show that the filaments which arise from the posterior and anterior columns, convey the impressions that excite muscular contraction; and that, of these latter, the posterior and anterior are antagonists to one another."*

* "De Medulla Spinali Nervisque ex ea Prodeuntibus." "With regard to the structure of the anterior roots of

Here Bellingeri returns partially to the origi-ginal doctrine of the present writer, by assign-

the spinal nerves, it is demonstrated, that they are composed of filaments, having a triple origin;—first, from the anterior bundles; secondly, from the region of the anterior lateral fissures; and lastly, from the lateral bundles. There are, however, some fibres which rise directly from the white substance of the anterior and lateral bundles; others which, perhaps, come from the anterior horns of the grey matter; and, lastly, there are some which come from the surface of the spinal marrow, and others from its interior. The anterior roots are composed of numerous nervous fibres having nearly the same thickness, each of which arises separately, approaches the neighbouring fibres of the same root, but does not blend with them: each fibre is about the size of a hair, and is never subdivided into smaller threads. The anterior roots, at least in man, do not enter the spinal ganglia.

"The posterior roots are composed of fibres rising in a triple order: the chief part comes directly from the posterior horns of the grey substance; other filaments, but few in number, have their origin from the white substance of the posterior bundles; others, in a similar manner, from the lateral bundles. Of the second and third sets of fibres some come from the surface, and others from deeper parts of the substance of the cord. There are filaments, however, which are finer than the others, being of the same size as the fibres of the anterior roots: these are not numerous. But there are other filaments much thicker and more numerous, being composed of many very small fibres, which are much interwoven, both with each other and with the neighbouring filaments, so that the fibres of the posterior roots can by no means be separated; and thus these roots and their filaments, both in their origin and course, present a platted form. Frequently the neighbouring posterior roots of the

ing muscular motion, as regards the extensors at least, to the posterior columns and nerves!

same side communicate with each other by means of nervous twigs; and these roots alone constitute the spinal ganglia.

"By instituting a comparison between the anterior and posterior roots, four circumstances may be remarked in which they differ:—1st, the filaments of the posterior roots are, generally speaking, thicker and less numerous than the filaments of the anterior roots; 2nd, The filaments of the posterior alone present a platted structure; 3rd, The posterior roots alone form the spinal ganglia; 4th, The neighbouring posterior roots almost all communicate by nervous filaments.

"All the filaments of the accessory nerves arise from the lateral bundles of the spinal cord, and penetrate deep into its substance; no communication intervenes between the accessory nerve and the posterior roots of the spinal nerves. Such is the case in the ox; but in the human subject, although the nerve has the same origin, it sometimes receives many or all the fibres of the posterior roots of the first pair; and occasionally, although but seldom, a filament of the same root of the second pair. But the accessory nerves do not retain these fibres, which, on the contrary, go to constitute or increase the posterior root of the first pair of cervical nerves."

But I give an abridged view, in the original Latin, of the chief features of the doctrine of this writer, without translating the physiological and least important part of it.

"Quoad structuram radicum anteriorum nervorum spinalium demonstratum est, hasce radices constare filamentis triplici ordine enascentibus, quorum alia a fasciculis anterioribus, alia in regione scissurarum collateralium anteriorum, alia denique a fasciculis lateralibus exoriuntur; sunt vero filamenta, quae directe enascuntur a substantia albida, vel medullari fasciculorum anteriorum, et lateralium; sunt alia,

Schoepf, in the Annali Universali di Medicina, Milano, Luglio, 1828, asserts that both roots of

quae fortasse oriuntur a cornubus anterioribus substantiae cinereae; sunt denique filamenta, quae a superficie medullae secedunt, sunt alia, quae profunde medullae substantiam subeunt. Radices anteriores conflantur ex pluribus fibris nerveis, eandem propemodum crassitiem habentibus, quarum unaquaeque sejunctim a medulla exoritur, vicinis fibris in data radice approximatur, sed nullomodo cum ipsa miscetur; unaquaeque fibra capillarem fere praesefert crassitiem, nulloque pacto in minores fibras subdividi patitur. Radices demum anteriores, saltem in homine, non ingrediuntur ganglia spinalia.

"Radices posteriores conflari a filamentis triplici ordine enascentibus; maxima enim pars filamentorum oritur directe a cornubus posterioribus substantiae cinereae; alia vero, sed numero pauca, oriuntur a substantia albida fasciculorum posteriorum; alia pari modo a fasciculis lateralibus; quae secundi et tertii ordinis filamenta sunt, alia secedunt a superficie medullae, alia profunde in substantiam medullae penetrant. Sunt vero filamenta, quae caeteris tenuiora sunt, et exaequant crassitiem filamentorum radices anteriores componentium, istaque filamenta numero pauca; alia vero filamenta multo magis crassa, et numero plura sunt, atque constant ex pluribus fibris quam exiguis, quae inter se multipliciter intertextae sunt tam in ipso filamento, quam cum fibris vicinorum filamentorum, ita ut nullo pacto omnes fibrae radicum posteriorum inter se separari possint, atque ita radices posteriores, eorumque filamenta jam in sua origine et decursu plexuosam praeseferunt formam; saepius vicinae radices posteriores in eodem medullae latere per nervea filamenta inter se communicant; et solae radices posteriores ganglia spinalia constituunt.

"Comparatione instituta inter radices anteriores, et posteriores elucescit, quatuor praecipue esse discrimina, quibus

the spinal nerves and both columns of the spinal cord are subservient to voluntary motion.

posteriores ab anterioribus distinguuntur: 1°. filamenta radicum posteriorum generatim magis crassa sunt, et numero pauciora filamentis radicum anteriorum: 2°. filamenta tantum radicum posteriorum plexuosam praeseferunt structuram: 3° solae radices posteriores ganglia spinalia efformant: 4°. vicinae radices posteriores fere omnes per nervea filamenta communicant.

"Filamenta omnia nervi accessorii exoriri a fasciculis lateralibus medullae spinalis, et profunde in substantiam medullae penetrare, nullamque intercedere communicationem inter nervum accessorium, et radices posteriores nervorum spinalium; haecque in medulla bovis: in homine vero eandem esse originem nervi accessorii, sed quandoque in se recipere omnia, vel plura filamenta radicis posterioris primi paris, et aliquando, sed raro, filamentum etiam radicis posticae secundi paris cervicalium; quae tamen filamenta nervus accessorius in se non retinet, sed rursus dimittit pro constituenda, vel adaugenda radice posteriori primi paris cervicalium.

"A cruribus cerebri tertium nervorum par, vel motor communis oculorum maxima ex parte enascitur, qui nervus unice motorius est; ab extremitate superiori corporum pyramidalium, quae cerebri productiones sunt, sextum par, vel nervus abductor oculorum exoritur, qui pariter unice motorius est; e lateribus externis dictorum corporum pyramidalium maxima pars oritur filamentorum duodecimi paris, vel nervi magni hypoglossi, qui nervus, communi physiologorum sententia, unice motibus voluntariis in lingua praeest. Igitur anatomes et physiologia suadent, cerebrum proprie dictum, ipsiusque productiones, motibus, et quaedam voluntariis, dicatum esse.

"Demonstrato itaque, et cerebrum, ipsiusque productiones motibus voluntariis praeesse, nervosque motorios voluntarios

To the same extent at least, then, as Bellingeri, Schoepf returns to the original doctrine of the present writer!

suppeditare, conjectari licet, filamenta radicum anteriorum, exorientia a fasciculis anterioribus medullae, motibus quoque, et quidem voluntariis, dicata esse.

"Quum ex anatomicis dubia adhuc admodum sit origo filamentorum radicum anteriorum enascentium in regione scissurarum colateralium anteriorum, an nempe ipsa filamenta a substantia albida tantum exoriantur, an vero perveniant usque ad contactum cornuum anteriorum substantiae cinereae, de usu istorum filamentorum dicere supersedemus.

"Putamus vero, filamenta radicum anteriorum, quae a fasciculis lateralibus enascuntur, functionibus organicis, vel ab instinctu dicata esse; cujus nostrae opinionis ratio, ex iis quae diximus de usu fasciculorum lateralium disserendo, elucescit. Ad roborandam hanc nostram opinionem accedit analogia e structura nervi spinalis accessorii desumpta. Profecto filamenta istius nervi a fasciculis lateralibus medullae exoriuntur, multaque ex ipsis ramum internum accessorii efformant, qui certe ramus copulatus cum trunco pneumogastrici, nonnisi organicas, et involuntarias functiones peragit. Credimus etiam, filamenta radicum anteriorum, enascentia e fasciculis lateralibus, ea esse, quae ad nervum intercostalem efformandum concurrunt; verum hac in re diligentiores anatomicorum observationes desideramus; felix si anatomicorum solertiam hac in re excitabo, et si observatione confutabor. Attamen non omnia filamenta radicum anteriorum, e fasciculis lateralibus medullae enascentia, unice in nervum intercostalem impendi opinor; sed plura ex ipsis partem nervorum spinalium constituere credo, et cum ipsis in varias corporis partes, in trunco, extremitatibusque distribui; in quibus dicta filamenta naturalibus, vel organicis functionibus famulantur, circulationi nempe, absorptioni, nutritioni, secretionibus, et temperiei animali.

Magendie now asserts, that neither sensation nor volition belongs exclusively to either series

"Jam vero filamenta ea, quae a fasciculis posterioribus oriuntur, motibus et quidem voluntariis dicata esse reputo, idque suadet evidens cerebelli influxus, et actio in motus voluntarios; profecto a cerebelli productionibus quartum nervorum encephalicorum par enascitur, qui nervus unice motorius est, et quidem voluntarius.

"Ea vero filamenta radicum posteriorum, quae a fasciculis lateralibus exoriuntur, iisdem usibus, functionibus nempe organicis, dicata esse opinor, uti similia filamenta radicum anteriorum.

"Superest inquirendus usus, et functiones filamentorum enascentium a cornubus posterioribus substantiae cinereae; haec vero sensui tactus animalis praeesse reputo. Solae sunt radices posteriores quae plexuosam in sua origine et cursu praeseferunt structuram; quae ganglia spinalia constituunt; et posteriores radices generatim filamentis magis crassis quam radices anteriores conflantur; insuper plura filamenta harum radicum directe cum cinerea substantia communicant. Porro istiusmodi characteres competunt nervis, qui sensibus animalibus dicantur, non autem nervis motoriis. Profecto nervus olfactorius, opticus, et acusticus evidenter a cinerea substantia exoriuntur, vel cum ipsa in sua origine communicant; quinimo olfactorius multa ex parte ab hac substantia compingitur; memoratique nervi plexuosam evidenter vel ganglioformem structuram praeseferunt; insuper, nervi isti nervis motoriis encephalicis magis crassi.—Contra, nervi motores voluntarii ex albida oriuntur substantia, nec plexuosam, neque ganglioformem in trunco structuram praeseferunt, et tenuiores sunt nervis sentientibus. Inter nervos motores voluntarios enumerandum tertium, quartum, et sextum par nervorum cerebralium, nervus insuper facialis, atque hypoglossus, quibus nervis omnes memorati competunt characteres.—Itaque ex dic-

of these roots. When the posterior roots, he says, are irritated, contractions are caused in

tis credimus, unice radices posteriores, non autem anteriores, sensui tactus animalis dicatas esse; et non quidem omnia filamenta ipsarum radicum posteriorum, sed tantum filamenta ea, quae directe a cornubus posterioribus substantiae cinereae enascuntur, vel cum ipsis directe communicant.

"Jam haec scriptis concredita erant, quum incidi in experimenta habita a Magendie, quae maxima ex parte nostram opinionem confirmant; nempe solas esse radices posteriores, non autem anteriores nervorum spinalium, quae sensui tactus praesunt. Ipsi tamen penitus assentire nequeo, dum statuit, radices posteriores, in motibus, nullum influxum exercere.

"Certum est, diversos et oppositos motus in humana machina absolvi; flexionis nimirum, extensionis, adductionis, atque abductionis, et ita porro. An credendum, indiscriminatim hisce motibus nervos, et nervea filamenta, quae a cerebro, cerebello, ipsorumque productionibus exoriuntur, inservire? An potius, nervos cerebrales unius generis motibus, nervos vero cerebellosos motibus alterius generis dicatos esse? Hoc postremum crederem profecto; et quidem nervos a cerebro, ipsiusque productionibus exorientes, flexionis, et abductionis motibus in genere famulari; nervos vero a cerebello, ejusque productionibus enascentes, generatim motibus extensionis, et adductionis esse dicatos.

"Re quidem vera, quartum par nervorum encephalicorum, motor internus, vel amatorius nervus nuncupatus, antagonista est sexti paris, quod motor externus, abductor, vel indignatorius nervus etiam dicitur; sed quartum par a cerebelli productionibus enascitur, sextum vero par a productionibus cerebri exoritur.

"Tertium nervorum par, vel motor communis oculorum, multiplices quidem, et oppositos oculorum motus regit, sed

the muscles to which their nerves are distributed, although the contractions, he says, are stronger when the irritation is applied to the anterior

duplex est ipsius origo, a cerebro nimirum, atque a cerebello; praeter truncum enim tertii paris a cruribus cerebri enascentem, sunt nervi accessorii ad tertium par, a Malacarne inventi et descripti, atque a Palletta delineati in propria tabula; qui nervi accessorii a cruribus cerebelli enascuntur.

"In lingua quoque, quae summa mobilitate donatur, variosque et oppositos exercet motus, nervi originis cerebralis, et cerebellosi inseruntur.

"Radices posteriores nervorum spinalium motibus extensionis dicatas esse, argui posse videtur ex anatomica structura medullae spinalis hominis, et animalium.

"Profecto vidimus, in homine, fere per totam extensionem medullae, fasciculos posteriores prae anterioribus magis crassos esse; quae major fasciculorum posteriorum crassities majus etiam robur radicibus posterioribus tribuere videtur; ast in homine frequentior positio est perpendicularis, sub qua recta corporis positione motus extensionis majori vi et robore indigent, quam motus flexionis. In regione vero cervicali superiori medullae bovis pariter fasciculi posteriores multo magis crassi sunt fasciculis anterioribus; quod ideo a natura factum esse opinor, utpote quod a fasciculis posterioribus secedunt nervi, qui per musculos caput sustentant. In regione vero dorsali medullae bovis fasciculi posteriores graciliores admodum sunt anterioribus; horizontalis enim corporis positio in bove efficit, ut minus roboris requiratur in musculis dorsalibus. Posito, fasciculos posteriores, et nervea filamenta ex ipsis orientia, motibus extensionis inservire, explico etiam cur fasciculi posteriores, unice in regione sacrali medullae avium, multo magis crassi sint anterioribus fasciculis; et sane, cum pedibus insistunt aves, mus-

roots. On the other hand, when the anterior roots are irritated, appearances of sensibility are caused. This, by the bye, only shows that M. Magendie's test, susceptibility of pain, is worthless.

In his " Expériences sur les fonctions des racines des nerfs qui naissent de la moelle épinière," M. Magendie says, " Presque toutes les fois que l'on excite ainsi les racines postérieures, il se produit des contractions dans les muscles où les nerfs se distribuent : ces contractions sont cependant peu marquées, et infiniment plus faibles que si on touche la moelle elle-même. *Quand on coupe à la fois un faisceau de racine postérieure, il se produit un mouvement de totalité dans la membre où faisceau va se rendre.*

" Ces faits sont donc confirmatifs de ceux que j'ai annoncés : seulement ils semblent établir que le sentiment n'est pas exclusivement dans les racines postérieures, non plus que le mouvement dans les antérieures.

In their "Anatomie des Systèmes Nerveux," Magendie and Desmoulins similarly say, "*La section d'un faisceau de racines dorsales cause une secousse detout le membre correspondant.*"—

culi extensores extremitatum inferiorum majori vi indigent ad totum corpus sustentandum.

" Pauca de obscuro hoc argumento dicam ; et subdubie proferam, substantiam cineream mihi videri dicatam esse sensui, albidam vero substantiam motibus obeundis."

"L'isolement des deux proprietés dans chacun des ordres de racines n'est donc pas absolu."

Thus Magendie returns still more completely to the original doctrine of the present writer, granting a share of sensibility to the anterior, and of influence over the muscles to the posterior nerves!

Thus, to say nothing of Sir C. Bell's first worthless and abandoned doctrine, he appears, even in his indisputable publications in 1821 or later (twelve years at least after the writer's first, and six years after his second, *series* of publications), to have asserted that the functions of these nerves respectively were the very reverse of those the writer had assigned them, simply in order to make such views his own. Bellingeri, however, concedes motion to the posterior column as the writer had asserted! Schoepf follows his example!! and Magendie unhesitatingly concedes a share of sensibility to the anterior, and of muscular influence to the posterior, roots, as the present writer had originally asserted!!!

Sir C. Bell's Acknowledgment of the Unsatisfactoriness of Experiments on the Roots of the Spinal Nerves, although they alone could afford any ground strictly logical for his inversion of the Writer's doctrine.

It is precisely what might have been expected, that, after all this, Sir C. Bell should acknowledge his experiment on the roots of the

spinal nerves in a *living animal* to be unsatisfactory! But, in a *dead rabbit,* he says, that "on irritating the posterior roots of the nerve, I could perceive no motion consequent in any part of the muscular frame; but on irritating the anterior roots of the nerve, at each touch of the forceps, there was a corresponding motion of the muscles to which the nerve was distributed.*

Again he says "the *impossibility* of arriving at a decided conclusion regarding the sensibility of these roots [the anterior ones], was the reason why he *left* his experiments as we find them, to prosecute the subject by observations and experiments on the fifth pair." !!! †

Muller also tried similar experiments on *living rabbits;* but he found "that the previous operation of opening the vertebral canal was so difficult, and attended with such excessive pain to the animals, as frequently to induce involuntary twitches of all the muscles even when the nerves were not directly irritated, so that he was precluded from deducing any satisfactory conclusions."

Muller, however, went still further from the right road, and had recourse to frogs, in which the nervous system is materially different, as wanting, or nearly wanting, cerebel, ganglia, &c.

* Nervous System, p. 31.

† Preface to the same work, p. 23.

—circumstances which cannot fail to modify more or less whatever operations are performed on their nervous system.

How boldly and distinctly, then, (the writer cannot help saying) does the original doctrine stand forward from the shuffles of the first of these anatomists, and the confusion of the rest! —The writer will now endeavour to explain the

CAUSES OF THE BLUNDERS COMMITTED IN THE INVERSION OF THE WRITER'S DISCOVERY BY SIR C. BELL AND OTHERS.

Erroneous conclusions from Diseases and Injuries.

Many attempts have been made to discover the functions of the various parts of the brain, by observing the effects of diseases or of injuries. There are objections, however, which are absolutely fatal to that mode of proceeding.

With regard to the effects both of diseases and injuries, the connections between parts and the sympathies which they evidence set at defiance all accurate conclusion; and with regard to injuries in particular, the cutting through intermediate parts in order to reach deep-seated ones, can produce only the grossest deception, for as the injury is compound, the effect cannot be the simple one sought for.

Here (happily, as we shall afterwards see) nature is in alliance with humanity, and thus distinctly forbids, as worse than useless, the performance of bloody and cruel experiments.

Utter Worthlessness of all Experiments on Living Animals, in which Functions are destroyed or disturbed.

To prevent cavilling, it is scarcely necessary to observe, that experiments on air respired, on various excretions—in short, experiments in which functions are neither destroyed nor disturbed, are not of the class here objected to.

Experiments, however, on the nervous system are generally of a different kind, as even the uninitiated will acknowledge, when they are informed, that, for such purposes, the head of a monkey, perhaps, or of a dog, is first screwed into a vice, or his body stretched over a log of wood and his legs nailed down upon it,—the skin of the head, or that over the spine of the back, is next cut through, with a knife—the living membranous or fleshy parts are then dissected or (to permit the subsequent operation of the saw) scraped from the bones,—amidst squeeling and convulsive struggles, the scull, or the long spinal canal, is opened with a saw—a difficult, and, if carefully done, long protracted operation,—convulsions still continue, and blood is poured out so incessantly, that, in spite of the perpetual application of sponges, any distinct view of the parts is impossible, utterly impossible,—and it is under all these circumstances, that a man, more brutal than

the beast he destroys, pretends to tell what he has done, while thrusting his knife through the parts of the brain, or into the spinal canal, still trembling and blood-gushing,—and it is after all this torture of vital parts, having numerous unknown connexions and sympathies, that he thinks the motions of the animal, exhausted with a succession of complicated tortures, afford him a simple and natural result!

Every where, indeed, has the folly, the cruelty, and the uselessness of experiments on living animals been practically exposed.

Even Magendie and Desmoulins now impute the principal results in Flourens' disgusting experiments to the compression caused by clots of blood formed during their performance!

In their work on the vertebrata, however, Magendie and Desmoulins proceed in the very same career! and it is enough to say, that one result of their experiments is, as they themselves assert, that the optic nerve is not that of vision, and that the trifacial nerve is the immediate organ of all the other senses!

The stupid experiments and monstrous conclusions of Magendie and Desmoulins are really undeserving of notice. So queer and dubious, indeed, are the results of these experiments, that M. Desmoulins thinks it necessary to take his oath, that they are all true; and he does so in the following form:—" Il faut écrire avec sa

conscience, en présence de Dieu, dans l'intérêt de la vérité ; je l'avais déjà fait dans ce livre !"

But to come nearer home.—In the experiment by which irritation of the anterior roots of spinal nerves produces motion, and irritation of the posterior none, and from which it is concluded, that the anterior roots are those of motion, and the posterior those of sensation, precisely similar blunders and absurdities are committed.

In this case, if the blunderers had known aught of physiology, and looked only to the effect produced in health when mutilation and injury are absent, there could have been no mistake.

It is a principle, taken for granted, even in these bungling experiments, that the sensitive nerves will naturally and best transmit their impressions to the brain, spinal cord, or involuntary nerves, and, through them, best excite the muscles to act.—Now, supposing a column or nerve of sensation to be artificially irritated, it is evident that the most natural and effective influence on motion must be its effect—the muscular parts must have instant excitement to act.

So surely is this action the natural effect of such excitement of sensitive parts, that, if the spinal cord of an animal be completely divided, and the sole of its foot be irritated, the

convulsive movement of its leg is accurately the gesture which the animal employs, when, in undisputed possession of sensation, it retracts its limbs from similar irritation.

The occurrence of action, in this case limited to the muscles of these extremities, only proves, that, independently of the will, under injury at least, a connection exists between the nerves of the skin and those of the muscles.

Here, however, Sir C. Bell would be as well warranted in concluding, that the skin is more properly an organ of volition than of sensation, as he is in his similar conclusion as to the anterior column and roots of nerves when muscular action follows their irritation. — Does he really conclude, that the skin of the sole of the foot is an organ of volition ?

No: but, in the face of these obvious truths, Sir C. Bell deceives himself; and adding another proof that want of fairness is inseparable from want of knowledge and ability, he still concludes that these very columns and nerves are those of volition !

He of course *reasons* thus, as shown in the Advertisement—that because the irritation of *cutaneous nerves*, by producing motion, *proves them to be* sensitive ones, therefore the irritation of *anterior spinal nerves*, by producing motion, *proves them not to be* sensitive ones;—or (if this form please him better) that because the irrita-

tion of *cutaneous nerves, by producing motion,* proves them to be sensitive ones, therefore the irritation of *posterior spinal nerves, by producing no motion,* proves them to be sensitive ones;—or that because the irritation of *ganglionic nerves* in the *chest,* by causing no increase of motion, *does not disprove* their being motive nerves, for, on them, the motions of the vital organs, indisputably depend, therefore the irritation of *ganglionic nerves* in the *spine,* by causing no motion, *does disprove* their being motive nerves;—that, in short, the strictest analogy and the closest reasoning are useless in physiology, and that ignorant and reckless experiment, especially when it is unexplained, or explained so as to contradict all living and healthy phenomena, is the test of perfect adaptation for physiological research.

In this experiment, the true explanation evidently is—that, by directly irritating the anterior nerves, we simulate *touch* upon their extremities,—that sensitive nerves, whether roots or branches, do naturally transmit such impressions of touch to the brain, spinal cord, or involuntary nerves,*—and that, through them alone, the muscles can thus be excited to act;

* It seems probable that any motion excited by irritation will always be involuntary, that is, dependent, not on the cerebel, but the lateral columns of the spinal cord. Thus in all experiments, the motion is below the point irritated, having passed directly through the cord.

—and further that, by directly irritating the posterior nerves, we do not simulate *volition* in the cerebel, or the impulse to involuntary action in the spinal cord,—that motive nerves, whether roots or branches, which have thus passed through their peculiar organs, do not obey an impulse which is entirely foreign to them,—and that accordingly the muscles cannot, by such inappropriate means, be excited to act; —and, moreover, that they can be the less excited to act, because, as in the nerves of the abdomen, which are evidently motive, ganglia prevent motion, so here is a ganglion on every one of these very posterior roots.

Here is an experiment, then,—perhaps the most remarkable ever made on the nervous system,—an experiment which, throughout Europe, has been repeated by all the writers on this subject,—an experiment which has stained the page of every physiological work in every language,—an experiment which not one of its instituters has, in the slightest degree, understood,—an experiment, for the explanation of which, these very instituters have laid themselves under obligation to an observer and a reasoner who has left to them the mutilation of his doctrine for five-and-twenty years!

Let, therefore, candid and honourable men now say, whether what they have just seen does most honour to the method of observation and

reasoning, or to that of experiment on living animals.—Let them say whether an experiment so gravely instituted, so universally performed, so often repeated, and of which not one of its advocates have, during a quarter of a century, been able to explain the nature, affords any token that the persons who do these things, have minds capable of understanding what they do,—or whether it has not afforded a signal proof that the observer with whom this doctrine originated, and to whom it was, after all, left to explain the act of these physiologists, has not pursued the better course.

Of the procedure and the capacity of these persons, there cannot be two opinions.—Still the undiscriminating advocate of experiment may say, "Well, we have, after all, benefited by the experiment, since it has now led to the explanation of it."—I deny this. I am satisfied that those who argue thus, know nothing of the real nature and application of experiment in physiology, and only carry about with them a remnant of that puerile love of external demonstration which characterizes the child incapable of understanding a *why* or a *because*.

Experiment is, indeed, valuable in any case to which it is applicable—that is, in any case where its apparent result is the direct and immediate effect of its performance, or an effect that, being easily traced and understood, illus-

trates the purpose for which it was performed.—But experiment is worthless, utterly worthless, in every case in which its living subjects present infinite relations and sympathies, in which unseen influences are exerted, in which phenomena intermediate to the experiment and its apparent result, are hid from the eye of the experimenter, in which there is consequently more chance of a wrong than of a right explanation —as the history of this experiment indisputably proves, and in which, at the best, and even when it is ultimately explained, the time of the explainer is wasted in the exposition of a blunder, instead of a natural law.

To make this still plainer.

What is here the cause of the failure as to just explanation?—The taking the result of the experiment, namely, the motion produced by irritating the anterior roots, for a direct or immediate result?

And why did the experimenters take it for a direct or immediate result?—Because they did not think of, much less understand, the structure of the intermediate parts.

Hence it follows that, before instituting any experiment of this kind, the intermediate parts —their beginning, their middle, and their end—should be completely unravelled, and their course distinctly traced.

But if these parts be unravelled and if their

course be distinctly traced, what will be the use of experiment?—None, absolutely none.

If even in a nerve of which the course were unbroken from organ of sense to muscle, an experimenter could artificially excite action in an inverse order, namely, from muscle to organ of sense, his experiment would be utterly worthless in the estimate of any man capable either of enlarged observation or of higher reasoning.

I cannot, I believe, better shew the total inapplicability of experiment to the nervous system.

Comparative anatomy and the observation of natural and healthy phenomena can alone shew the course of natural action; while artificial excitement and force, as even by pinching, from root to branch, successive parts of a nerve with forceps, is as likely to cause retrograde as natural action.

I have put this reasoning in the clearest form of which I am capable, and in little paragraphs, because, while these gentlemen have been making experiments, which were understood by nobody, on the nervous systems of animals, they have innocently been making one, which must now be understood by every body, on their own nervous system.

The rage for experiment on living animals will now be easily understood.—All fools have eyes and fingers. They rejoice that some fan-

tastic use of these may be called experiment. This becomes a happy compensation for the want of reasoning powers. The number of pretenders naturally renders the method universal. And each blockhead thinks himself wise when he has made an experiment which he does not understand.—Henceforth let these men know that amplitude of eye and hand is a wretched substitute for littleness of brain, and that reasoning powers are essential to all advances in physiology.

In his experiments on the anterior roots of the spinal nerves, in mammiferous animals, M. Magendie found that, when these were divided close to the chord, and irritation was made on the roots, no sensible effect followed, whereas whilst their connexion with the chord was preserved, the slightest irritation was productive of effect; and the nearer it was made to the chord, the more intense was the influence occasioned by it.

Now this might have led M. Magendie to the truth as to the anterior roots; for it is evident that no sensible effect followed their irritation when divided from the chord, because no motion resembling a sensitive one could in that case so easily reach the anterior columns, or ascend through them to the cerebel—the former producing involuntary, the latter voluntary motion.

The following are the words of M. Magendie

in his "Expériences sur les Fonctions des Racines des Nerfs qui naissent de la Moelle Epinière."

"Cependant une difficulté pouvoit s'élever.—Quand, dans les expériences qui précèdent, les racines ont été coupées, elles étaient continues avec la moelle épinière: l'ébranlement communiqué à celle-ci ne serait-il pas la véritable origine, soit des contractions, soit de la douleur qu'ont éprouvés les animaux?—Pour lever ce doute, *j'ai refait les expériences* après avoir séparé les racines de la moelle; [This evidently was anxiously and carefully done; and mark the result] et *je dois dire qu'*excepté sur deux animaux, où j'ai vu des contractions quand je pinçais ou tiraillais les faisceaux antérieurs et postérieurs, dans tous les autres cas *je n'ai observé aucun effet sensible de l'irritation des racines antérieures ou postérieures ainsi séparées de la moelle.*"

The perfect accuracy of M. Magendie's statement as to the effects of this experiment in the higher animals, is supported by the circumstance that its result is opposed to his views; and that he felt this, his "je dois dire," in the preceding quotation, sufficiently proves. There was, therefore, no room here either for negligence or haste.

It appears, however, that in frogs, motion can be excited, by means of the anterior roots, even

when they are detached from the posterior columns.

Professor Muller, of Bonn, has published the results of his experiments on these animals, which are to be found in a late Number of the "Annales des Sciences Naturelles."

"When the posterior root," he says, "is divided, the animal appears to experience 'quelque douleur:' if the distal or unattached portion be now seized and irritated, there is not the slightest trace of movement in any of the muscles of the trunk, or of the extremities. When the anterior or abdominal root is simply touched, convulsive movements of the extremities immediately follow: the same phenomena, only more violent, are observed when this root is cut and irritated.

"The galvanic experiments were performed at first with a single pair of zinc and copper plates. Upon applying the two plates to cut ends of the anterior roots, the muscles became convulsed; but no such effect was ever produced when they were applied to the posterior roots."

This difference of result in two different classes of animals, must of course depend on the difference of structure characterizing each.

Now, we find in the frog, that the cerebel, on which voluntary motions depend, if it can at all be said to exist, is reduced to a narrow line, and the spinal cord, on the lateral co-

lumns of which involuntary motions depend, is immensely increased. In other words, we find the superior part of the cerebro-spinal system becoming less important, and the inferior becoming more so.

It is not less certain, that, like the spinal cord, the nerves of the lower animals obtain a corresponding encrease and importance compared with the central parts of the system. It cannot, therefore, be surprising that their reciprocal influence should be greater.

As Mr. Bauer has shown, that when a portion of recent brain, brown and white, is examined by a high magnifier, the rows of globules pass, without interruption or change of direction, from one part to the other,—as this motion may be seen by the projection of the cut ends of any nerve on pressing it in the middle,—as we can compel a retrograde flow of blood for a short space either in artery or vein which in that case is relieved by anastomozing branches, —it is evident why the pressure of a detached anterior spinal root, always proceeding with the point of the forceps from the root to the branches, should there also cause a retrograde movement of nervous globules, to be similarly relieved by anastomozing branches, and to effect more or less of motion by calling many or few of these into action.

The peculiarity, therefore, which occurs in

this case is probably owing to this, that when in the frog the detached anterior nerve is thus compressed from root to branches, a retrograde action is established down to the points of junction of the nerves of this particular pair with those which are given off from the cord both above and below, of which the branches run parallel with this, and which always join it by subordinate branches, or at all events with voluntary or involuntary nerves from the posterior roots.

It seems probable, indeed, that these communicating branches exist for this very purpose of supplying the defective action or obstruction of each other; and this is perfectly analogous to what exists in the vascular system.

It is not wonderful, then, that, in a class of animals in which mere nervous action becomes relatively more important than cerebral, and in which all the parts and all the functions of that system become more independent of each other, such interchange of action should be greatly facilitated.

It is further remarkable that, in frogs, on the longitudinal filaments of the sympathetic which run along each side of the spine, and which are every where connected with the very roots in question, those ganglia which exist in higher animals and which obviously intercept nervous action, are remarkably defective.

In the still inferior class of fishes, ganglia are still more defective—in most of them, indeed, nearly, if not completely, wanting; and could they be as easily experimented upon, it is probable that these communications or interchanges of action would be found to be still more easy.

It seems to me probable, however, that some considerable degree of the same effects should be found in birds, and even in mammalia, but that it should no doubt be less and less as the central predominate in importance over the external parts of the system, and as the ganglionic apparatus encreases.—Precisely such appears to be the case from M. Magendie's acknowledgment.

Blunders as to the Greater Organs from not understanding the Results of Experiments.

As, however, in direct opposition to all evidence and reasoning, these anatomists called the anterior roots and columns motive, and the posterior sensitive, it became necessary for them to prove, that the brain, with which the anterior are connected, is the organ of motion, and that the cerebel, with which the posterior are connected, is the organ of sensation.

That the hemispheres of the brain, however, have no direct influence over locomotion is proved by the circumstance that their removal produces no change in the habitual walk or

gesture of animals.—But let us hear what even M. Magendie acknowledges upon this subject.

"The cerebral hemispheres may be cut deeply into the different points of their superior surface, without any marked alteration of motion taking place.

"Even their entire removal, if not extended to the anterior striated bodies, produces no appreciable effect; except what may easily be referred to the suffering which such an experiment must induce.

"The results are not alike in all the classes of vertebral animals: those which I have described, have been observed in the mammifera, and especially in dogs, cats, rabbits, guinea-pigs, hedgehogs, squirrels.

"In birds, the removal or destruction of the hemispheres, the superior tubercles remaining entire, often gives place to a state of sopor and insensibility which was first described by M. Rolando: but I have seen, in a number of cases, the birds run, leap, swim, when their hemisphere was removed.

"In reptiles and fishes upon which I operated, the removal of the hemispheres seemed to have very little effect upon their movements; the carp swam with agility, the frogs leaped and swam about as if they were quite untouched, &c. &c., nor did sight appear to be abolished.

"The spontaneousness of our motions, then,

does not appear to belong to the hemispheres exclusively, as a young physiologist has recently advanced. This fact (true in certain birds, as pigeons, adult crows," &c.—Query) " does not hold in other birds, and is entirely inapplicable to the mammalia, reptiles, and fishes ; at least, to the species which I have myself submitted to experiment.

" The longitudinal section of the superior commissure and its removal, produce no additional effect upon the motions."

I here the more readily quote M. Magendie's experiments, because their results are directly opposed to his own doctrine and that of Sir C. Bell, and because he is fully sensible of this.—He says, conformably with that doctrine, " La disposition anatomique indique que le sentiment doit [that is, consistently with his perverted view of it] se diriger plus particulièrement vers le cervelet, et le mouvement vers le cerveau : mais l'anatomie ne suffit pas ; il faut que la physiologie et les faits pathologiques viennent confirmer l'indication. Or jusqu'ici ni l'un ni l'autre de ces moyens n'a etabli ce que l'anatomie semble montrer d'une manière si évidente. *Les lésions du cervelet ne font point perdre la sensibilité. La soustraction des hémisphères n'emporte pas necessairement la perte du mouvement.*"—This is an important and decisive acknowledgment.

So much for the brain not being the organ

of motion, according to the avowal even of these experimenters.

Notwithstanding the innumerable facts, however, in proof of the opposite, Sir C. Bell and MM. Fodéra, Foville and Pinel Grandchamp imagine the cerebel to be the organ of sensibility, because it suits their erroneous notion as to the posterior roots and columns.

But that the posterior columns and roots are evidently prolongations of the cerebel, which so many observations prove to be the organ of volition, and to control the motions of the body, is an evident indication of their functions.

Rational Method of prosecuting Physiological Inquiry.

As, then, everything shows the worthlessness of experiments on living animals, the rational method of prosecuting physiological inquiry is, evidently, as already stated, 1st, accurately to ascertain structure and to observe healthy phenomena; and, 2dly, to recur to comparative anatomy and physiology, in which the dissections and experiments of nature may be found.

Carus, in his Comparative Anatomy, vol. i. p. 275, accordingly says, "It appears worth while to inquire, whether the investigation of the nature of the mental faculties may not be promoted at least as much by such anatomical comparisons as by the performance of rude experiments on the brain of living animals? and

which process, of the two, is generally most suited to the nature of the object."

Tiedemann also, with great truth, says,—"Comparative anatomy unveils to us the origin and successive developement of the brain and nervous system, from the most simple animals up to man, the most complicated. There is no set of organs, in the formation of which we find so perfect a gradation from the simple to the compound, as in the cerebral and nervous system: in fact, this system is established on an uniform plan in the whole animal scale. So, in studying the gradual complication of the structure of the brain in animals, can we have a clear idea of the complex organization of the viscus in man, and at length succeed in comprehending its assemblage and relations. As by the study of the brain and nervous system of animals we can alone arrive at the knowledge of the gradation which the former undergoes in its formation and progressive complication, so also shall we have need of a comparative psychology to conceive the uses and manner of action of each portion which composes this mass. We must observe attentively the phenomena of cerebral action, from animals the lowest in the scale up to man, and then compare them with the structure of the organ itself. This comparative study of the actions and organization of the brain in different animals will

dispel the cloud over the functions, devolving on its separate parts—*a knowledge to be derived from no other means than those already mentioned.*"

Even Sir C. Bell says, "Experiments have never been the means of discovery [in anatomy]; and a survey of what has been attempted of late years in physiology will prove, that the opening of living animals has done more to perpetuate error than confirm the just views taken from the study of anatomy and natural motions."*

But, in reality, it never was experiment on living animals, with all its horrors, its difficulties, and its uselessness as to all rational conclusion, that led to the blunders of Sir C. Bell.

Sources of these Blunders in previous Hypotheses.

When Sir C. Bell placed the nerves and columns of sensation behind those of volition, every physiologist will see that he misled himself by some vague notions about the crossings and decussations of parts.

Now, he might have observed that there are no crossings between anterior and posterior parts, and that even those between lateral parts are few in number.

The crossing of the optic nerves may have been one source of this error. But this cross-

* Nerv. Syst. p. 218.

ing, as I shall afterwards show, is necessary only in the eye.

Touch has nothing to do with distant objects, and has no minute aperture for the admission of their impressions: it therefore could admit of no crossing. Both hands extended reach but a short way, and any crossing of them or of their nerves, would only have inverted objects to the brain.

So, also, as to smell, hearing, and taste, there is no crossing: see the parallel course of the olfactory nerves, which might so easily have crossed, if, in the eye, crossing had not been an exception from a general law, and applicable only to vision.

The decussation of some fibres of the pyramidal bodies is not essential to the general functions of the spinal cord, as composed of anterior and posterior parts; for it is slight in the lower mammalia, slighter in birds, and absent in reptiles and fishes.

The contemplation of the trifacial nerves or 5th pair with their ganglia, appears also to have led to these blunders.

Erroneous Conclusions as to the Trifacial Nerves.

The reader has already seen Sir C. Bell's acknowledgement that "the *impossibility* of arriving at a decided conclusion regarding the sensibility of these roots [the anterior ones],

was the reason why he left his experiments as we find them, to prosecute the subject by observations and experiments on the 5th pair." All direct arguments from the spinal chord or roots connected with it are thus wonderfully lowered in value, if not virtually abandoned ; and we have only to try the doctrine delivered by these gentlemen in regard to the trifacial nerves—their *dernier resort!*

Mr. Mayo says, " it appears that the fifth nerve consists of two portions, one of which has no ganglion, and is a nerve of voluntary motion (and probably of muscular sensation), and another, which passes through a ganglion, and furnishes branches, which are exclusively nerves of the special senses. Soemmering compares the fifth pair of nerves with the spinal nerves: by this analogy I was led to conjecture that the double roots of the spinal nerves have functions corresponding with those of the fifth, and that the large posterior portion of each spinal nerve, with its ganglion, belongs to cutaneous sensation, and the posterior branch to voluntary motion. When I was engaged in experiments to determine the fact, M. Magendie's were published, which established the justness of my conjecture."

Now Mr. Mayo's analogy between the trifacial nerves and the roots of spinal nerves is bad ; for the ganglia on the sympathetic nerve, with

which the trifacial are far more closely associated,* appears to be the sole means of preventing conscious sensation; and, from so clear a case, he might rather have concluded that the fifth would not exhibit sense, though it might suffer from pain.

This is conformable with Dr. Copland's observation, "that the ganglionic portion of the fifth nerve is *not only a sentient nerve*, but that it also is *engaged in the functions of secretion exerted by the parts which it supplies*, namely, the lachrymal secretion, the secretion of mucus in the nares, and the secretions of the mouth;" for, I would add, *it must effect these by fibres devoted to vital and involuntary action.*

That on the ganglionic portion of the trifacial nerves, vital and involuntary motions depend, is further proved by its ophthalmic branch aiding in the motions of the iris, and by its extensive and large distribution to the muscles.

Mr. Mayo himself (Physiology, p. 310.) says, "It is to this class of nerves (those having ganglions near their origin), that physiologists have commonly attributed the unconscious influence, which is exercised by the nervous system over nutrition. This conjecture does not appear to be without foundation." And he mentions various cases to show that where the trifacial nerve

* In fishes and reptiles, the trifacial appears to be the only cerebral pair with which the sympathetic nerve is connected.

was injured, inflammation, ulceration, and opacity of the eye occurred.

Now one is certainly at a loss to see how *sensation* should *exert an unconscious influence* over nutrition, or should *resist morbid conditions of the vital functions* of these parts. But if we suppose the trifacial to controul the involuntary actions of these parts, the explanation is easy.

In sensation, the motion is from the circumference to the centre, and therefore not of a resisting kind: in involuntary action, it is from a centre to the circumference, and therefore of a resisting kind. And indeed every observation seems to prove that, on the almost incessant involuntary or voluntary actions of parts, depends their resistance to injury of this description.*

* These views explain the errors committed respectively by Sir C. Bell, Mr. Mayo, and M. Magendie, in the three following paragraphs.

Sir C. Bell acknowledges a *loss of the motion of the lips in eating*, in consequence of dividing the superior maxillary branch of the trifacial nerve;—but he ascribes it to the loss of sensation! (Nerv. Syst. p. 74 and 82.)

Mr. Mayo says that he divided the branches of the second and third divisions of the trifacial nerve, where they emerge upon the face in an ass, which deprived the lips of sensation, and though *their apposition did not remain quite as exact as before*, they did not lose their tone or fall from the teeth, but *the animal ceased to use its lips in taking up its food*;—and this last circumstance he imputes to the mere loss of sensation!

M. Magendie says, "I have found in my researches upon the trifacial nerve that the section of the trunk of that nerve, made

As indeed the ganglionic portion of the trifacial supplies, among other parts, the membranes lining the cavities of the nose, mouth, &c., just as the sympathetic supplies the cavities of the thorax and abdomen, it will now, I believe, appear that that portion of the trifacial is, like the ganglionic nerves of the viscera, a nerve generally both of sensation and motion, for it largely supplies both cutaneous and muscular parts, as well as secreting ones, which must rank with the latter, in having action *from* the brain—exactly the reverse of a nerve of mere sensation.—Its unganglionic portion may be a nerve of voluntary or involuntary motion alone.

The assertion, I must now observe, that all nerves of sensation have ganglia, is contrary to fact. The day has gone by when the anterior striated bodies could be called the ganglia of the olfactory nerves, or the posterior striated bodies the ganglia of the optic nerves; and if the inferior tubercle be called the ganglion of the olfactory, the superior tubercle that of the optic, and the grey band that of the auditory nerve, then it must also be granted that these

within the cranium, *arrests the motion of nictitation*;"—yet for all this, he thinks, "the muscles of the eyelid are not paralyzed: the light of the sun introduced suddenly into the eye still produces winking."—The distribution of this nerve to the muscles of the eye will evidently account for this, as well as its sensibility.

nerves have other terminations on which there are no ganglia, while *those terminations on which they exist, are actually at points where, as will afterwards be seen, they join nervous bundles of a different character;* and they therefore afford striking and decisive arguments in favour of the truth, that *ganglia exist, not on pure nerves of sensation, but only where nerves of different character unite!*

A law indeed of great importance and beauty springs out of this, namely that—as the higher intellectual system disappears in the inferior classes of animals, exactly so do ganglia, which seem necessary to unite that system with the nervous system of life. Hence ganglia can with difficulty be found in reptiles, and disappear in fishes.

And it is after all this, that Sir C. Bell considers his experiments on the trifacial nerves as "making certain what could be only *assumed* from the experiments on the spinal nerves!"*

Having thus disposed of these gentlemen's last resort, in the trifacial nerves, I now proceed to deal with its appendix, in the facial nerves or seventh pair.

Erroneous Conclusions as to the Facial Nerves, &c.

Here I must premise, that vital and mental sensation or action appear throughout the sys-

* Nerv. Syst. p. 109.

tem, to have different nerves even in the same organ.

To account for the facial nerve being largely distributed to the surface, Sir C. Bell (Nervous System, p. 237.) says, "The influence of the mind is conveyed to the surface. The condition of the mind in passion, for example, is as forcibly communicated to the skin as to the muscles themselves; and therefore . . . the seventh is necessary to the change of *vascular action* and to the condition of *the pores* when affected by a cause proceeding from within outwards."

Now this is a mere evasion.

When the peculiar influence of the mind is conveyed to the surface in the expression of passion, it is directed to the muscles; and the change of vascular action and the condition of the pores are mere adventitious associations of vital action therewith. The negro has the same distribution of the facial nerve to the skin, and the same muscular expression dependent upon it; but his dark hue dependent on the vital system, renders any obvious change of complexion impossible.

Nor is this all.—The vessels, belonging as they do to the vital system, appear everywhere to be supplied by nerves belonging to that system, namely, branches of the sympathetic, which may be traced upward upon the carotid and

downward upon the femoral arteries. The facial nerves, therefore, can have nothing to do with *vascular action* and *the pores* of the face.

The distribution, therefore, of the facial nerve to the skin, is directly opposed to Sir C. Bell's hypothesis.

The circumstance that both the facial and the ganglionless portion of the trifacial supply different and distinct muscles about the lower jaw—one class being subservient to expression, and another to vital purposes, clearly indicates the difference in the character of these nerves.

The experiments of these anatomists on the facial nerves throw additional light on the trifacial, if that were now required.

Mr. Mayo says that he divided the facial nerve of both sides in an ass, which completely paralyzed the nostrils and lips, the latter falling from the teeth and hanging pendulous, and the animal making no use of them in attempting to take food.—And this last is precisely what Mr. Mayo acknowledged as the result of dividing the trifacial!

Sir C. Bell says, "On cutting the respiratory nerve of the face in the carnivorous animals, it did not appear that the action of feeding was left *so entire* as in the graminivorous animals."*—Thus it is acknowledged that the action of feed-

* Nerv. Syst. p. 83.

ing was left "so entire" in graminivorous animals, notwithstanding the facial being cut, and the trifacial being alone to be depended upon!

To conclude, then, as to the facial nerves, they appear to be at once nerves of conscious sensation and of voluntary motion. They supply both cutaneous and muscular parts; they evidence sensibility, as Messrs. Mayo,* Fodéra, Shaw, and Muller *acknowledge,* while Magendie asserts that, if we may judge from the struggles and cries of the animal, they are *very* sensible (an argument, however, to which I attach no importance, weighty though it should be with the experimenters); and they end, on each side by two distinct cords penetrating the medulla oblongata, which shall afterwards be shown, and which must decide the point with all who prefer anatomical facts to unfounded hypotheses.

* "If a nerve known to belong to the sense of touch, by the immediate insensibility of the surface, which it supplies, incurred on its division, be divided, and the portion next the brain pinched with the forceps, in a living animal, indications of violent pain are given. Such an injury of the branches of the fifth [a nerve of sensation, according to Mr. Mayo] in a living ass is attended with the result mentioned, which, however, does not ensue when the portio dura [a nerve of volition, according to Mr. Mayo] is pinched in that animal. I had conjectured that a general criterion to distinguish nerves of cutaneous or similar sensation might be derived from the preceding remark; but I have since found, that in animals less patient than the ass, as the cat and dog,

It is scarcely necessary to observe, that Sir C. Bell's argument, that the anterior column belongs to motion, because the general oculo-muscular nerve is in contact with the crus cerebri, the external oculo-muscular with the pyramidal body, &c. is worthless, because these nerves actually pass through these inferior parts to others above them!

Erroneous Confounding of Sensibility with Susceptibility of Pain.

The anatomical errors of these gentlemen, or rather their accommodating anatomy to their hypothesis, is less pardonable perhaps than their incapacity for metaphysical discrimination.

The difference, however, between pain and

the irritation of the portio dura [this nerve of volition] produces an expression of pain, distinct though not as violent, as that resulting from an injury of the fifth!"

Speaking of these experiments upon asses, and particularly of Mr. Bell's first ass, M. Magendie says—" Nous avons répété cette expérience, mais l'animal, au moment de la section, témoigna, par ses efforts et par ses cris, qu'il y était fort sensible. Nous ne doutons point cependant du fait rapporté par M. Bell; mais cela montre combien on doit être réservé quand il s'agit de *généraliser* un résultat."—M. Magendie is of opinion, that there may be a *difference* in the degree of sensibility or of *sentiment*, as the French call it, in asses.—To me it seems that there is very little difference between French and English animals of that description.

sensation is throughout confounded by them—a very curious and universal error, as well as the real source of all the blunders of these anatomists—a point, in fact, which when cleared up, sets the whole matter at rest.

We have been led to connect pain with touch, because as pain may be found where there is no vision, nor hearing, nor smell, nor taste—as it may be produced throughout the surface of the body, and as touch also extends over this surface, they have been naturally associated.

The object of the sense of touch is form. If pain, then, belong to the sense of touch—what is its form?—Pain gives no form, smell, taste, colour, or sound: it is therefore neither touch, smell, taste, vision, nor hearing. Yet pain in a lacerated nerve is Sir C. Bell's test of that nerve being a nerve of sensation!

But supposing pain to be exclusively dependent on nerves, it is by no means probable that it is dependent on those of touch, which is a peculiar mode of sensation; for not only does pain leave us unacquainted with the peculiar objects of touch, but, in the human body, each peculiar mode of sensation has its peculiar nerves. The nerves of smell, vision, and hearing do not evidence pain when injured; and analogy is therefore altogether in favour of the nerves of touch being equally exempt from it.

So far, therefore, as nerves of touch, or those

of any other mode of sensation, enter into the composition of the anterior roots and anterior columns of the spinal cord, pain should, under no circumstance, be evidenced by them.

Even M. Magendie states that, by observation in the depression of cataract, the retina is entirely devoid of sense—meaning thereby unsusceptible of pain; and as the optic, olfactory, and auditory nerves are equally so, it should have led him to the fact, that parts of specific sensation are unsusceptible of pain.

Indeed, the appropriation of all ascending nerves or bundles to purposes of specific sensation, appears universally to incapacitate them for pain. Moreover, the organs of sense are guarded from injurious impressions by peculiar contrivances, as the eye by eyelids, the ear by the membrane of the tympanum, &c. and all impressions are modified in the organs themselves, before they are transmitted to the brain in perception. And this seems a happy arrangement, for otherwise perception and the other functions of the brain might have been perpetually disturbed, if not altogether annihilated.

Accidental injuries to the surface of the brain prove also its insensibility to pain. It was, therefore, unnecessary for the experimenters on living animals to show, as they have done, that the greater part, if not the whole, of the cerebral hemispheres is insensible to puncture, laceration, section, cauterization, &c.

It is evident, then, that none of the nerves ascending to it—that is nerves of perception are likely to have properties of which the central part is divested.

Pain connected only with descending Fasciculi.

In the work, however, of MM. Magendie and Desmoulins on the nervous system of the vertebrata, is furnished the most striking, and, if their own observations are to be depended on, most decisive proof, that pain is unconnected with the ascending or sensitive and perceptive bundles, and dependent entirely on the descending or motive bundles.

"*The lobe of the 4th ventricle,*" say they, "where the consciousness of sensation [an obvious error!] resides in mammalia, and also *the will, or the faculty of being determined,* in reptiles and fishes, *enjoys an exquisite sensibility;* and the cerebral lobes, in which the faculties of understanding and instinct reside, are altogether insensible."

Now the anterior roots of nerves and anterior columns of the spinal cord indisputably terminate in the thus insensible though general perceptive organ, and the posterior columns and posterior roots of nerves indisputably proceed, by means of the restiform bodies, from the thus sensible though motive organ—for the organ of "the will or the faculty of being determined" is of course the motive organ.

It would thus appear that susceptibility of pain is connected alone with willing, determining, motive or descending bundles—for all motive bundles must of course be descending ones.

Pain connected with those Bundles in particular on which Life depends.

From many circumstances, it would appear that pain is connected only with that portion even of the descending bundles on which life more immediately depends.

The central part of the bundles of the oblong process, on which life appears to be peculiarly dependent, is exquisitely susceptible of pain; and it is therefore probable that, on its bundles alone, that feeling is dependent.

A corroboration of this last view, is afforded by the statement of many physiologists, that pain and danger are greater in proportion as injury approaches the white parts situated in the basis of the cranium.

It is true that the abdominal nerves and ganglia are generally unsusceptible of pain; but this is probably owing to their remarkably slight connection with the brain; for when their condition under noxious agents or injury is such that it affects the brain, no pains are more acute. The trifacial nerve too, which is distributed to the commencement of the vital cavities, and which seems to differ from the sym-

pathetic chiefly in having a larger connexion with the brain, is susceptible of pain, and is therefore well calculated to guard the inferior parts of the vital system from injury.

The cause of Pain, and the conclusion to be drawn from it.

The cause, then, of the derangement affecting the nervous system during pain may be the separation more or less perfect of vital parts, and the consequent obstruction of vital functions that ensues. Pain accordingly is actually less at the moment of touch than afterwards. Hence the sense of pressure, especially when a cut part is pendent; and hence the cessation of pain on the re-establishment of union.

Now motive, as well as sensitive parts may be divided, obstructed, and rendered painful; and therefore, pain, even if it could be equally the condition of either, would afford no test for distinguishing nerves of one kind from nerves of another.

It may, however, happen, that, if obstruction of function, pressure, &c., be the cause of pain, pain may be greatest when nerves of motion are cut—the very reverse of Sir C. Bell's assumption.

If, indeed, such obstruction be the cause of pain, must not the degree of obstruction, or the degree of pressure, at the point, determine the degree of pain? And if so, where, in the nerv-

ous system, would the pressure, &c. be greatest? In the least, or in the most, advanced part of the system?—Probably in the most advanced

The separation of a nerve of sensation should not cause the greatest pressure, &c. on the common sensorium: it should indeed rather remove it by rendering new and accumulated impressions upon it impossible. On the contrary, when impressions from all the senses have accumulated—when their power has been multiplied in the brain—when the impulse to external motion has taken place—when this rushes to its termination in the force necessary to muscular action—then, indeed, obstruction, pressure, &c., and their reaction on the system, must be excessive.

It appears, indeed, possible that the pain arising from division and other injuries, depends, locally at least, on the branches of the sympathetic investing the divided vessels. But if so, as these minuter filaments equally belong to motive and sensitive nerves, it must be an egregious error to consider pain as the test of any particular nerve being a nerve of sensation.

Circumstances as to Pain, which prove that it has nothing to do with Touch or common Sensation.

It is remarkable that pain, in the case of a cut or similar injury, is not an instantaneous effect; some time elapses; and it would appear that some new action is always set up before it is felt; the

vessels are evidently excited; the blood is poured out; and the pain absolutely increases for some time afterwards.

Now, if touch and pain had been the same, or had depended on the same nerves, the injury done to the sense of touch and the pain suffered would have existed at the same instant of time.—This seems to me to be a strong proof that pain and touch are essentially different.

Nor is this all: it appears that if even an extensive wound be inflicted with extreme rapidity, not even the slightest sense of touch shall accompany its infliction, and the flow of blood or the loss of limb shall announce the injury.—It seems evident therefore that touch and pain depend on causes entirely different.

Nor is even this all: the arguments hitherto employed are derived from the general organ of touch itself — the surface of the body; but pain may exist in internal organs which are never liable to the sense of touch, and where two circumstances elsewhere so universal, cannot be confounded.—It seems therefore certain that there is neither connexion nor analogy between susceptibility of pain and the sense of touch.

Finally, when the sensibility of the skin to touch has been lost, it has remained sensible to heat and consequently susceptible of pain.—This appears to me to be absolutely decisive as to this point.

In all these cases, pain is shown to be different from touch, by the former existing distinctly from and independently of the latter. But it may also be shown, that these may exist in the same part, at the same moment, and still remain distinguishable from each other.

If upon any healthy surface, two impressions of form be at the same time made, they will be observed to be indistinct in proportion to their complexity; and that evidently because they are of the same kind. If, on the contrary, upon any inflamed surface, in which pain already exists, any impression of form, simple or complex, be also made, it will thereby become only the more distinct; and that evidently because touch differs in its nature from pain, and is rendered more distinct by being contrasted with it.

To me, it seems that no additional argument is required to prove, that pain has nothing to do with touch or common sensation.

Conclusion as to Pain.

Thus it is impossible to contemplate this question without seeing that—if in the cutting or laceration of nerves, pain depend on the branches of the sympathetic investing the divided vessels, it must be equal in nerves of motion and nerves of sensation,—and if it depend on obstruction of vital functions descending, it should be ac-

tually greatest in nerves of motion—the very reverse of Sir C. Bell's expectation.*

Finally, all the organs in the body have their specific functions; and pain is not one of these. The natural and healthy action of these is always pleasurable; and this evidently depends on their connexion and harmony. The reverse, then, of this—pain, must depend on their separation and want of harmony, and not upon any specific sense. That separation must cause the interruption or the effusion of blood, perhaps a loss even of nervous matter; and it is impossible that this should not derange the vital or the nervous system, without any nervous fasciculi being appropriated to a purpose so accidental, so unfunctional as the communication of pain. I say so unfunctional; for pain is but the rude, general and indiscriminate consequence, not of the existence, but of the destruction of function and of the organization on which it depends, and provision is everywhere made for averting it, and not for its maintenance and direct communication to the centre of the nervous system.

* It seems to me probable, that the sensation of temperature belongs to the nerves of the vital system, not only because on that system animal heat depends, but because the means of modifying the impression of external heat depend on that system.

CONCLUSION.

Thus the writer thinks he has proved, as to the anterior columns and nerves, that irritation of them produces muscular motion, solely because they are ascending or sensitive columns and nerves, and therefore the natural means of exciting muscular motion; and, as to the posterior columns and nerves, that their asserted greater susceptibility of pain has nothing to do with any of the five specific modes of sensation, but probably depends on bundles descending from the oblong process which is itself peculiarly susceptible of pain—bundles connected with vitality or life as is the organ from which they descend.

Thus, consequently, he thinks he has proved, that the inversion of his original doctrine, which now pervades and constitutes the more important features of the physiology of the nervous system, has been brought about by a series of extraordinary devices, mistakes, and blunders; and that, therefore, the doctrine as it originally stood, as it has been sketched in the preceding pages, and as it is extended in the following work, is the true one.

As to the mere vindication of his long priority which this preface contains, the writer has shewn, that:—

1st, In 1809, namely twenty-five years ago,

the writer published the true doctrine of the nervous system, —*a.* ascribing sensation and action to distinct nerves and columns, —*b.* ascribing these truly, viz. sensation to the anterior, and action to the posterior nerves and columns;

2dly, In 1811, namely two years after the writer's first publication, Sir C. Bell (as he now avows) printed, but never published, a pamphlet, in which he neither ascribed sensation and action to distinct nerves and columns, nor ascribed these truly, but on which, till Mr. Mayo's exposure of its falsity, he pretended to found a claim of having, even so late as that, in any degree indicated even so little, as merely that these distinct functions belonged to distinct parts;

3dly, In 1815, namely six years after his first publication of this doctrine, the writer repeated and extended it in Thomson's Annals of Philosophy,—still ascribing sensation and action to distinct nerves and columns,—and ascribing these truly, viz. sensation to the anterior, and action to the posterior nerves and columns;

4thly, In 1821 or later, namely twelve years after the writer's first, and six years after his last publication, Sir C. Bell, for the very first time, went so far as to adopt even the first part of the writer's doctrine, viz. to ascribe sensation and action to distinct nerves and columns, which he tried to appropriate to himself,—by inverting the second part,—calling the anterior

nerves and columns motive, and the posterior sensitive,—wrongly indeed—but still thereby endeavouring to make the whole his own, and rob the writer of the entire merit of long prior discovery.

5thly, Thus the little to which either Sir C. Bell or M. Magendie have presumed to lay claim, namely the ascribing distinct functions to distinct nerves and columns (and ascribing these wrongly, as the writer has shewn), dates twelve or thirteen years after this was done (and done rightly) by the present writer.

And what, then, shall be thought of the conduct of those who have tried to plunder the writer as he has shewn?—Why, that they are utterly destitute of that elevating and proud knowledge that makes men scorn to steal thoughts from others.

When, however, the writer reflects on the weakness, the fear of authority, the timidity, of mankind, he believes that he has no reason to regret this; but rather to fear that they will not approve the other far more important truths in the following work—precisely because they may not yet have been stolen! Knowing this, it may be said, he has no one to blame; and this, he really believes, is the right spirit in which to take the thing.

THE NERVOUS SYSTEM.

PART I.

SENSATION.

The physiology of the organs of sense is here briefly sketched, only in so far as it was necessary to the more important sequel of the work, that certain newly observed and very interesting relations of the modes of sensation, to intellect and will or volition, should be explained.

As subordinate to this, it was desirable to give some explanations as to vision, and an account of the uses of the parts composing the labyrinth of the ear.

These latter, however, I regard, on the present occasion, as trifling compared with the relations of the modes of sensation to intellect and will, forming the last chapter of this Part, and still more trifling compared with the cerebral functions which occupy the second and third Parts of the work.

CHAPTER I.

THE ORGANS OF SENSE GENERALLY CONSIDERED.

THE number, doubling, position, &c. of the chief organs of sense first demand our attention.

Why (exclusive of the sense of heat and others belonging to the vital system) are these organs precisely five in number?—This evidently is the case, because there are just so many states of matter capable of mentally affecting animals, and so many media in which they are involved. These are solids which affect touch, liquids which affect taste, aeriform fluids which affect smell, sonorous vibrations which affect hearing, and light which affects the sight.

The states of matter, properly so called, are indeed only three, namely, solidity, liquidity, and fluidity, and require only three organs, namely, those of touch, taste, and smell; but it is obvious, that the other two senses, of hearing and seeing, were indispensable to such a per-

fectly organized animal as man, in consequence of his being enveloped in the two great media of the atmosphere and of light. Had still other media existed, there would probably have been still other senses.

Why, also, are some of the organs double and others single ?—Desirous of rendering impressions in the more perfect animals as numerous, extensive, and powerful, as is consistent with their organization, nature, instead of giving them one organ of sense, as to the zoophytes, has bestowed upon them five ; and conforming to that which is nearly a general law, has doubled these organs whenever it was possible ; permitting them to be single, only in those cases where certain other circumstances, it will be seen—certain complex offices, which they had also to perform, rendered the doubling of them impossible.

Thus, the ear performs only the office of hearing, and consistently with this principle, it is double. The eye performs only the office of seeing, and, in similar consistency, it also is double. But the nose and the mouth do not perform only the respective offices of smelling and tasting—they perform also that of speech. Now, it was necessary that the voice should be single. Hence, the parts of the nose are closely approximated, and the mouth is a single organ.

It is true that these form two different organs,

thus performing one function—the function of voice; but it is worthy of notice, that nature has adapted them for the performance of distinct portions of that one function: articulation consequently takes place in the mouth; resonance, in the nose. It is further worthy of notice, that these two organs, in so far as they are two different organs of sense, receiving impressions from without, are externally separate; and in so far as they form one and the same organ of voice, proceeding from within, they internally communicate.

Why likewise have these different organs situations so very different; two of them, the eye and the ear being placed superiorly, and two, the nose and mouth, inferiorly?—The eye and the ear are elevated in order to command objects placed at as great a distance as possible; and the nose and mouth, which do not receive impressions from a distance, are placed below, in order to permit a ready communication with the lungs and stomach.

Nothing could have been more inconvenient than the situation of the nose and mouth above the eyes, not only as it would have elevated senses which do not command distant objects, above a sense which ought to command them, but as it would have required an unnecessary length of the canals which communicate with the lungs and stomach, would have

exposed the eyes to injury from food, would have removed the latter from the superintendence of sight, &c.

The reason, also, why the ear in particular is placed behind the eye, is, that, while any object of vision must necessarily occupy a limited situation, and be best inspected by an organ placed before, sounds, on the contrary, are diffused all around, and can more completely be impressed on organs situate on each side. Ample room is thus also given to the organs necessarily placed before—a situation which corresponds with the direction of locomotion.

The reason, moreover, why the nose is placed higher than the mouth, is not only that it is destined to command objects—odours namely, from a greater distance than the mouth, which, for the purposes of taste, must have liquids brought into actual contact with it, but there is another reason for their situation, which has a reference to their use, as the organ of voice. All resonance (of which the nose, as already stated, is the organ) tends to ascend; and hence, the nose, in order to perform that office --to permit resonance, must be placed above the mouth—the organ in which articulation is actually produced.

The organ of touch not being placed in the face, together with the other organs of sense, but at the tips of the fingers, is owing to this,

that the organ of touch is neither, like the eye and ear, affected by media universally diffused, nor, like the nose and tongue, by objects which are easily transported to them, but by solids, which are sometimes not easily moved, and sometimes require an organ of a certain length and flexibility to come in contact with their various parts. Hence, it has the present situation. Moreover, even if solids had all been easily movable, and readily applicable to a fixed organ, yet as the hands must have been employed to move them thither, it was evidently, in many respects, most advantageous that the organ of touch should reside in themselves: unnecessary movement is thus avoided, and the quickest and most accurate knowledge of objects is acquired. It is for these reasons, then, that the organ of touch, instead of residing in the face, like those of the other senses, is borne about at the tips of the fingers.

These three questions have, apparently, been neglected;* and, with regard to the last, it may be justly observed, that, if it be worth the while of the naturalist to remark, that the habit of the rays, of lying on their belly, renders it necessary for them to have eyes in the back of their head, as is exemplified in the skate, for eyes

* The preceding views respecting them were first quoted, with acknowledgement, from my lectures, by Dr. Pitta, in his "Treatise on the Influence of Climate."

in the front would be buried in the sand,—it surely cannot be unworthy of the physiologist to assign the reasons for the situation of individual organs in man.

We have next to inquire into the best order of enumerating, or arranging the organs, of which we have thus explained the number, the circumstance of their being double or single, and the different situation.

Some enumerate them thus: touch, taste, smell, hearing, seeing; and others exactly reverse this order.

The first arrangement, commencing with touch, is the order of the accuracy of these organs; for touch is the most accurate of the senses, because it consists in the actual contact of solids, which are the least variable state of matter; taste is less accurate, because it consists in the contact of liquids, which are more variable; smell is still less accurate, because it consists in the contact of fluids, which are more variable still; and hearing and seeing are least accurate of all, because they do not consist in any actual contact, but depend upon the interposition of media—air and light. Hence, the echo utterly deceives us, as to the direction of sound, and the oar, which appears perfectly straight in the open air, seems bent when partially plunged in water. This, then, is the order of their accuracy.

The opposite order, commencing with the sense of sight, or hearing, is the order, if we may so term it, of their dignity. The eye may be regarded as the noblest organ, because it commands objects at the greatest possible distance; the ear commands objects which are nearer; the nose, those which must be wafted to it by the air; the taste, those which are applied to it in liquids; and the touch, those solids with which the organ must be carried into actual contact.

CHAPTER II.

TOUCH.

Touch is the fundamental and elementary sense, of which all the rest are mere modifications. It is, moreover, the sense most universally diffused among animals, from man to the polyp that feels even light.

Carus talks of touch consisting, primarily, in the power of merely discriminating between an individual and the objects external to it. But it is a clever animal that "knows itself," even in this limited sense of the word. To do so, requires perception and consciousness. Primarily, touch seems not to enable an animal to do more than distinguish between mere limited parts of its surface and the objects external to them.

Even in the higher animals, touch, exercised by the head, bill, or lips, or by the feet or tail, is very imperfect. Some apes, indeed, have more numerous organs of touch than man; but none even of these animals have them so perfect.

Considering the skin generally as the organ of touch, we may observe that it consists of three layers—the true skin or corium, which is the internal, the mucous net-work or rete mucosum, which is intermediate, and the cuticle or scarf-skin which is external.

The true skin is composed of dense and tough fibres, interspersed with blood vessels and nerves. Its external surface is especially vascular and nervous. In each of its projecting filaments or papillæ, it is probable that a nervous fibril terminates, so as to constitute the organ of touch.

The mucous net-work keeps the papillæ in that state of moisture and mobility which is essential to sensation. This net-work is dark in the negro, in whom sensibility is greatest.

The cuticle, which is inorganic and insensible, by covering the nervous papillæ, retains moisture and prevents rude impressions on the subjacent parts. It is thin, smooth, and flexible; and the oily and aqueous secretions which pass through it are abundant. In proportion to the frequency or strength of impressions, it is gradually thickened to give increased protection to such parts.

As contact is necessary to touch, the perfection of its organ must depend on pliability as well as sensibility. The motions of the hand of man are accordingly numerous, and it may be easily applied to any form. This is aided by

the length of the thumb and the power of separating the fingers.

By supporting the tips of the fingers, the nails form the bases of the rest of the mechanism of touch; and the principal of the other important conditions superadded to these, are the breadth of the extremities of the fingers, the thickness of the fatty substance under the skin, the elasticity of the cellular tissue, the moderate thickness of the true skin, the numerous vessels which supply it, the size of its nerves and nervous papillæ, the moisture of the mucous net-work, and the thinness of the cuticle.

The extremities of the fingers in particular, and the palm of the hand generally, are covered with slightly elevated slender lines arranged in a spiral or oval form, each line presenting to the eye, numerous points between minute breaks and slight depressions.

These seem to be much more important organs than is commonly imagined. They tend to the retention on the fingers of any minute object which we feel. They seem also to afford a measure or mode of appreciating any minute form, which we consequently roll gently over them. It seems probable, therefore, that it is in them, that the nerves of touch commence, and that they are the peculiar organs of that sense.

The nerves of touch are those which termi

nate in the anterior spinal roots, as is evident from motion, which always follows sensation, being equally excited by the irritation of either.

Touch, which is properly an active sense, when slightly aided by the muscles, makes us acquainted with the form of bodies fundamentally, either as masses or as composed of particles evidenced on their surfaces.

With farther aid from the muscles, in more palpably moving, it makes us acquainted with the distance, dimension and connexion of bodies; but beyond very narrow limits, sight is necessary to these purposes.

In further conjunction with the muscles, in pressing, or resisting pressure, it makes us acquainted with solidity and gravity.

Touch has properly been called the geometrical sense, because it regards solids, the least variable state of matter, and because it appreciates the length, breadth and thickness of bodies, and transmits to the brain only strict and mathematical results. It furnishes us with the most distinct and accurate ideas, and it moreover corrects the inaccuracies of all the other senses.

This fundamental sense may acquire so high a degree of perfection from habit, as even to take the place of some of its modifications. Blind persons have been said, by it, to distinguish colours and even their shades, as well

as to perceive their approach to a wall by effects produced on their skin, by means doubtless of the air, and in the same manner probably as bats, which by the nerves distributed upon the expanded membrane of their wings, receive impressions from a change in the resistance or motion of the air in such cases.

It is remarkable that the animals in whom touch is the most perfect, as beavers and elephants, are even the most social and civilized; while great acuteness of sight and hearing may be combined with the most savage nature.

It must here be noticed that parts, in internal structure, analogous to the compound eyes of insects, are found combined with the sense of touch, in many of the inferior animals. In many genera of the order gasteropoda, are two little black points, placed sometimes at the extremity, sometimes in the middle, and sometimes at the base of the tentacula, which have been deemed eyes.

It would appear, however, that in these cases, the black coat, as in compound eyes, is external to what is called the retina; and comparative anatomists complain lamentably of the difficulty of understanding how, under such circumstances, vision can take place.

The appearance of pupils in compound eyes, observed by Muller (to which Dugés adds an iris contracting and dilating!) appears to be altogether deceptive. Carus says, "there is

not any trace of a separate iris or pupil : it therefore caused me the more surprise, that in examining the eye of the gryllus verrucivorus from its outer surface, it should have appeared to present a pupil, as in the eye of superior animals. This appearance, which I soon found likewise in the eyes of the libellulæ and some butterflies, was disproved by closer observation," &c.

Is not, then, the white matter, well supplied with nerves, in these eyes, analogous to a portion of the true skin of the higher animals ; the black matter, to the mucous net-work, which is dark in the negro whose sensibility is greatest; and the exterior substance to the cuticle, in itself insensible even in man, and horny in insects, because their general surface is more or less so, but furnished with fine hairs, which in them are separated and supported by the hexagonal facets, and descend through the black substance to the true skin and its nervous fibrils.

The circumstance that, in many animals, these organs exist at the same time with single eyes, and *that* in animals, as the subterraneous mole-cricket, which peculiarly require touch, seems to corroborate this.

I had written the three paragraphs preceding the last, when I observed from Carus, that Troxler had "doubted" whether these eyes should not be considered as papillæ of the skin, organs of touch, rather than of vision. If

this is accurately expressed by Carus, as a doubt only, we may conclude that Troxler adduced no arguments on the subject — more especially when we observe that Carus seems to pass it as a doubt, and that he even decides against it.

The analogies, however, which I have here mentioned seem to me to be nearly decisive on this subject. It is probable that, by this means, atmospheric films, steams, and even the minute matter of odours, may be touched by insects, as light is by the polyp; and hence their devious course through the air, after their mates, &c.

"The structure of the eye of insects," says Cuvier, "is so very different from that of other animals, even the mollusca, that it would be difficult to believe it an organ of sight, had not experiments, purposely made, demonstrated its use; for, if we cut out, or cover with opaque matter, the eyes of the dragon-fly, it will strike against walls in its flight. If we cover the compound eyes of the wasp, it ascends perpendicularly in the air, until it completely disappears; and if we cover its simple eyes also, it will not attempt to fly, but will remain perfectly immovable."

How futile these arguments are, need scarcely be pointed out. The same results would occur if these were organs of touch, equally essential to the guidance of insects.

CHAPTER III.

SMELL.

Those mollusca which live entirely in water may perhaps be supposed not to have the sense of smell. But snails and sepiæ which live partly in air, and other snails which live entirely in it, seem to possess smell, though distinct organs of that sense have not been discovered in them. It may exist in the whole surface of their bodies, on the surface of their respiratory cavities, in their feelers, &c.

As to fishes, it has been said, that a sense employed entirely in water to determine the quality of its contents must be taste, not smell —a sort of extension of taste. The senses are no doubt intimately connected, and approximate more or less in their nature and means; but as water contains air, which acts on the branchiæ of fishes, it may easily convey sensations of smell. Even in animals living in air, odours can impress the fibrils of the olfactory nerve only through the liquid which lubricates the nasal membrane. Moreover, that the

sense in question is smell, seems to be proved by the first, as a distinct pair of nerves, supplying it. It is probable, therefore, if not absolutely certain, that, in fishes, this sense distinguishes the odorous particles with which water is impregnated.

In man, the organ of smell, being subservient to the vital system, is placed in the beginning of the passages for respiration.

The cribriform or perforated plate of the ethmoid bone is at once in the base of the brain and at the upper part of the nasal cavity. The floor of that cavity is formed by the same bones which constitute the bony palate inferiorly. It is divided longitudinally and in the median plane by a bony and cartilaginous partition. Its lateral parts are formed by various bones and cartilages. On these, project inward the turbinated bones; the superior on each side depending from the ethmoid, and the inferior being a separate bone which is fixed below these. The narrow passages for the air toward the lungs are on all sides of these bones — above, between and below, and are called the superior, middle, and inferior conduits or meatus.

The vascular mucous membrane lining the nose, is soft and fungous, thicker over the turbinated bones, and thinner and firmer in the connected cavities, and is always moist from the secretion of mucus.

The sensibility of this surface is partly due to the olfactory nerves, of which the bulbs rest on the perforated bony plate, send filaments through all its apertures, and spread over the partition and the internal surfaces of the superior turbinated bones, constituting the sense of smell; and partly to branches from the trifacial nerve which spread over the whole of its surface and constitute its sense of touch, from pungent and other bodies.

The purpose of the external nose is doubtless to direct air bearing odours toward the superior part of the nasal cavities, the forms of which are well calculated to receive them. Persons accordingly who have no external nose, or a small or deformed one, have little or no sense of smell. The posterior nostrils which open into the pharynx, permit the passage of air to the throat, and a communication between the senses of smell and taste.

Smell informs us of the nature of bodies in relation to the vital system, and especially of those used as food. But perhaps its primary use is to inform us of the purity of the air we breathe.

Snuff destroys the sensibility of the nose, and its consequent utility as a means of varied information and pleasure, and it also injures the resonance of the voice. As even the subjects of this indulgence dare not deny these consequences, I need not dwell upon them.

The indulgence in snuff-taking and smoking tobacco, is however nearly as injurious to the mind as to the sensibility of the nose.

The slave of such practices, indeed, will tell you (for the meanness of sensual indulgence is always connected with the meanness of falsehood), that they whet his intellect,—as if the ever and anon withdrawing the mind from useful to useless operations, were the way to improve it—as if incessantly repeated external distractions from all thought, were the means of concentrating and invigorating intellect.

The truth is, that these are low indulgencies for which there is no rational apology; while they miserably increase the wants and the dependence of the indulgers.

But this is not all: these vices make their victims disagreeable to every cleanly person near them.

As to snuff-takers, the filthy napkins filled with the encreased discharge of mucus and the most abominable secretions, which are necessarily carried about their persons, render them objects of disgust among civilized men.

As to smokers, the blowing of dirty smoke, the belchings, eructations, and intestinal noises, the squirting of saliva in which hours and days are spent by them, their bestial stupidity of look, owing to the intellectual perpetually sinking under the indulgence of the vital system, their

rotten teeth, diseased gums and horrible stench, are really disgraceful to human nature.

On the subject of the cavities or sinuses which open into the nose from the frontal, ethmoid, sphenoid, and upper jaw bones, it appears to me that Blumenbach errs in thinking them chiefly connected with smell. Were they reservoirs of odour, as he supposes, they would prevent the succession or alternation of smells being as rapid as the application of successive or alternate odours, so that these would be entirely confounded. They certainly belong, on the contrary, to resonance of voice.

Besides, observes a friend, if the air filling them were once charged with odorous effluvia, it would be impossible for any other impression to follow, until the cavities received from without, a supply of air free from all odoriferous particles—a change not easily brought about. For resonance, on the contrary, no such change of air is requisite.

CHAPTER IV.

TASTE.

The organ of taste, being subservient to the vital system, is placed in the entrance to the alimentary canal and immediately within the organs of mastication.

Taste is of course more perfect according as the nerves of the tongue are larger, its papillæ more numerous and delicate, its skin thinner and moister, its surface more extensive, its substance softer, and its motions easier and more varied.

In fishes, the tongue cannot be considered as an organ of taste, because it has scarcely any motion, is generally composed of cartilage, and is covered by an insensible membrane, or even armed with teeth.

In reptiles, the tongue is in general more completely formed than in fishes; but it must still be very imperfect as an organ of taste. The adhesion of the tongue to the jaws, in frogs, sa-

lamanders, and crocodiles, prevents its free motion.

The bone in the tongue of birds diminishes its flexibility. In this class, parrots alone seem to have a tongue so soft and fleshy that it can be considered as a true organ of taste.

In quadrupeds, the tongue is more perfect than in any of the preceding classes, owing to the absence of bone within it, and the softness of its coverings. Most, however, of the herbivorous animals have their tongue covered by a thick cuticular coat, forming numerous pointed papillæ directed backward. Many of the carnivorous kind, as the cat, have the tongue covered by sharp and strong prickles, which enable them to take a firm hold. Even in those quadrupeds which have it most perfect, as dogs, &c. it is subservient to prehension as much as to taste. Blumenbach observes, that he knows of no animal in which the tongue exactly resembles that of man; as even in apes it is distinguished by its narrower and more elongated form, and by the difference of the various kinds of papillæ with which its upper surface is beset.

The integuments of the tongue resemble those of the skin.

Inferiorly, we find a papillary membrane somewhat resembling the true skin.

This is supplied by a branch from the trifacial

nerve, which is distributed to its muscles, to its mucous membrane and to salivary glands, and the division of which is said to destroy sensation; by the glosso-pharyngeal nerve, which is distributed to the surface of the root of the tongue; and by the hypoglossal nerve, which is distributed chiefly to its muscles, and the division of which deprives it of the power of moving.

Over and around such of the extremities of these nerves as are superficial and belong to sensation, the mucous net-work, or rete mucosum is thrown; and externally there is an epithelium performing the office of cuticle.

Mr. Mayo, who appears to be very accurate as to structure, says that mucous follicles cover the tongue for an inch from its root; that conical papillæ fourteen or fifteen in number, are arranged before the follicles in such a way that a central one is situated posteriorly, and the rest diverge toward the edges of the tongue, each being lodged in a little cavity, to the centre of which it adheres by its apex, while its base, slightly hollowed, forms part of the lingual surface; that oval or conoid papillæ are next arranged in ranks parallel to the last over the whole remaining surface of the tongue; that filiform papillæ are seen at the edges of the tongue; and that lastly, fungiform papillæ are

interspersed, among the oval or conoidal, over the tip and sides of the tongue.

Some of the lingual papillæ are doubtless appropriated to the sense of touch; and others perhaps, to that of heat. As on the application of a sapid substance, the fungiform papillæ are said to erect themselves upon the surface of the tongue, it is thought that they belong to taste, more especially as their situation is also that where the sense of taste is most vivid.

As to the nerves of this organ, the same anatomist says that, upon dividing the hypoglossal in animals, the tongue loses the power of motion; and that upon pressing it immediately after death, the muscles of the tongue are convulsed; but that on similarly pinching the branch from the trifacial or the glosso-pharyngeal, no spasm of the muscles follows; and that in a case in which every portion of the trifacial had lost its influence, the sensibility of the root of the tongue remained.

There is much, however, yet to be done as to this organ.

The state of liquidity is essential to taste; and the pressure of the tongue against the palate is necessary to the perfect exercise of its function.

I am inclined to think that the sense of taste said to be felt about the soft palate, &c. is always

a mere modification of touch, or a sensation of heat or cold, or an affection of the sense of smell.

Taste more properly enables us to judge of nutritive and hurtful substances.

Spices, wines, and spirits, destroy the delicacy of taste, and deprive us of the means of pleasure which it affords, which must thenceforward be derived from the quantity instead of the quality of food and beverage, inducing the sottish indulgence of repletion and intoxication.—This leads me to make a few remarks on food and beverages, which I cannot do better than derive from my own experience.

Being early impressed with the notion, that the breeding of animals for the knife was a remnant of the savage state, wasteful in the highest degree of the resources as to food which the earth offers to man, and brutalizing many beside the mere butcher, and being at the same time disgusted at the idea of chewing the flesh, the fat, the humours, the sores and injured parts of animals, which are often besides in a state of general disease, I abandoned the use of flesh as food; and I continued this for six months.

By this time, the mere odour of cooked meat became very disgusting to me, and extended my distate to all animal productions. For the following twelve months, I therefore used only bread, water, and occasionally, though rarely,

fruit; nor during that period, was this practice or experiment broken in a single instance.

I owe it to truth and to humanity to state that, under this diet, my strength of body was unabated, and the clearness, freedom and vigour of my mind were greatly increased.

With regard to beverage, I should also observe that, happening, in subsequent life, to get into the habit of drinking wine and water after dinner, though this was always in such moderation that I never once was tipsy, I yet observed that a second glass became more desirable than the first, and this alarmed me. I clearly observed or foresaw the steps by which even men who are not especially prone to such indulgence become ultimately drunkards, useless and disgusting both to themselves and others.

It, at the same time, struck me, that I had done less during the years of this practice than previously. On strict examination, I found that this was really the case; and, on closely observing the operations of my mind, I further discovered, that I really had not the same love of intellectual pursuits as formerly, and that in particular I shrunk from and avoided such discussions, as required the greatest keenness and activity of mind.

This of course was enough. In spite of the suggestion that sociality would be sacrificed (a

lying suggestion in which selfishness and sensuality seek for their apology) I "dashed down the cup" of wine, and—took up that of coffee in its stead. The stomach, thus cheated of its usual stimulant, soon became satisfied; scantier excretions, a cleaner mouth, a clearer head, were the speedy consequences; intellectual objects resumed their influence over my mind; and sociality was enhanced a thousand-fold.

CHAPTER V.

SEEING.

The eye consists of coats, of which an anterior one is transparent, of similarly transparent humours within the coats, and of a nerve expanded between the opaque coats and the humours.

In man, two coats may be considered as constituting the integument and case of the eye. These are in the form of a larger posterior and smaller anterior cup, applied to each other at their margins, and containing, in their cavity, the other essential parts.

The larger posterior cup, of which the cavity is turned forwards, is termed the sclerotic coat. It is composed of filaments interwoven in every direction, possesses opacity, tenacity, and flexibility, and determines the shape of the eye, as well as furnishes a firm support for the insertion of the muscles which move it. This coat is perforated posteriorly, for the passage of the optic nerve, and it has a circular aperture anteriorly for the reception of the edges of the next coat.

It extends over about four-fifths of the ball of the eye.

The smaller anterior cup is termed the cornea. It is a segment of a smaller sphere than the globe of the eye, is formed of thin concentric plates, united together by a compact cellular substance, and is dense, elastic, and transparent. It is thickest in the middle, becomes thinner towards the edges, and, in man, its edges are bevelled, where it slides under the sclerotic coat.

Immediately within the sclerotic, is the choroid coat, a thin membrane of highly vascular structure. It is slightly connected with the concave surface of the sclerotic by cellular tissue, and by the blood-vessels and nerves which supply it. Its concave surface is compact and uniform in texture.

Towards its anterior part, and near its termination, the choroid is more intimately connected with the sclerotic by means of a circular band of dense cellular or fibrous substance, termed the ciliary ligament or annulus albus.

From this band, many laminated processes project into the cavity of the eye, and form a broad radiated ring, termed the ciliary processes.

After forming the ciliary ligament, the choroid may be said to proceed on the inner surface of the sclerotic, to its junction with the cornea,

when it forms another projection into the cavity, termed the uvea, an annular curtain with its inner diameter variable.

The anterior surface of the uvea, opposite to the transparent cornea, is covered and connected with a membrane of spongy texture, termed the iris, which is the seat of the colour of the eye.

The space thus left is termed the pupil.

The iris is itself insensible to the impressions of light, but is influenced by every affection of the retina in that respect (a point, however, on which some doubt is thrown by cases of gutta serena, in which a free dilatation and contraction of the pupil is said to have been observed); and it readily expands or contracts, and thereby enlarges or diminishes the size of the pupil. The late professor Monro is said to have shown that the iris consists of two orders of fibres, an external or radiated which dilates, and an internal or circular which contracts, the pupil. The ciliary nerves which supply this organ, are derived from two sources, the lenticular ganglion, and the nasal branch of the trifacial nerve.

As the aperture is diminished when light is intense, and enlarged when it is deficient, the chief use of the iris seems to be to regulate the quantity of light admitted into the eye. In the eye of the cat, parrot, and hawk, the contraction

of the iris is often voluntarily performed; and it would sometimes appear to be similarly exercised in man.

On the slightly villous inner surface of the choroid, ciliary processes and uvea, is a mucous pigment, usually dark coloured, and therefore termed the pigmentum nigrum, which seems calculated to absorb the rays of light which have passed through the retina or expansion of the optic nerve, to be afterwards described.

Animals which exercise the functions of vision in the evening or night, have, on the posterior part of the choroid or that opposite the pupil, a light coloured space, of various hue, called the tapetum, by which a portion of the rays must be reflected.

Thus formed, the cavity of the eye contains humours of three kinds, the vitreous, crystalline, and aqueous.

The vitreous humour nearly fills the cavity, occupying all its posterior and middle part, or more than three fourths of the globe of the eye. It is convex behind, and concave before.

This humour is invested by a thin transparent membrane, termed the hyaloid, from which numerous membranous processes pass inwards, to form cells for the liquid, which is of the consistence of the white of egg, and does not readily escape from these cells, even when the external membrane is punctured.

The crystalline humour or lens, is toward the centre of the forepart of the cavity; its posterior side resting in a concavity of the vitreous humour. It is a double convex lens, of which the anterior surface is flatter than the posterior.

The substance of the crystalline humour is gelatinous, and denser at the centre than near the surface. On being hardened by boiling, or by alcohol, it appears to consist of concentric laminæ, formed by fine fibres. These are represented as proceeding from a centre at each extremity of its axis, where is the appearance of a membrane disposed in rays, whence the fibres originate, the rays of one extremity being opposite to the interstices of the other.

This humour is loosely enclosed in a membranous capsule, which is soft and transparent. Moreover, upon approaching the margin of the lens, the membrane of the vitreous humour divides into two layers, of which the posterior passes behind the lens, and adheres to its capsule, while the anterior passes upon the fore part of the lens, and unites with the capsule.

The channel left between these layers and around the edge of the lens is termed the canal of Petit, and may be inflated with air.

The aqueous humour occupies the remainder of the cavity, in front of the crystalline, and behind the cornea. This humour is less viscid

than the vitreous, is not lodged in cells, and readily flows out when the cornea is punctured.

The form of this humour is regulated by the parts which confine it. It is divided by the iris into two chambers ; the anterior, or largest, occupying the space between the iris and the cornea; and the posterior, that between the uvea and ciliary ligament.

The retina, in the form of a delicate transparent membrane, is expanded on the concave surface of the choroid coat, without adhering to any part of it, and extends from the base of the ciliary processes before, to the optic nerve behind. Its surface which is next the vitreous humour, is firmer than that next the choroid coat; and, in some animals, these surfaces can be separated. About two lines external to its concentration in the optic nerve, the retina presents the central hole of Soemmerring, with yellow edge and fold, which are found only in man, apes, and some reptiles.

The retina is affected by the rays of light. Its most sensible portion seems to coincide nearly with the tapetum of quadrupeds; the whole extent of perfect vision is very limited; and this is the reason that one part of the retina appears to be habitually used for accurate vision.

There is a point of the eye which is insensible to light, and which may be shown to correspond

with the place at which the optic nerve enters, or, more accurately, with that at which the central artery penetrates it.

The optic nerves, formed by the concentration of the fibres of the retina, and penetrating the choroid and sclerotic coats, are two in number, and, in all the higher animals, they cross more or less completely; the nerve from the right eye passing in part at least to the left side of the brain, and the nerve from the left eye, in part at least to the right side. In man, each nerve sends a portion to both sides of the brain; so that the crossing is partial.

Now, rays of light emanate from luminous bodies in all directions; and the eye, thus briefly described, is an optical instrument for the reception of these and of impressions on the retina, indicative of their colour. Those rays of course can alone reach the retina which fall on the transparent cornea, from which, however, some are reflected and give its brilliance to the eye. Those also which pass the cornea but fall on the iris are reflected.

No object is visible, unless the angle formed by its extreme points exceeds thirty-four seconds of a degree.

If many rays enter the eye from each point of an object, it is evident that, to render an impression distinct, all the rays which proceed from any one point of a body, must

be collected in one point of the retina. Accordingly, any cone of rays, falling upon the convex and transparent cornea, must undergo a change of direction and converge, an effect which is supposed to be increased by the humours of the eye; so that this brings all rays entering the pupil from a single point, to a local point, where the retina is spread out to receive the impression.

To render impressions distinct, it is also necessary, that all the points of union thus formed, should be arranged on the retina, in the same relation to each other as in the body whence they proceed.

Now, the rays of light which reach the eye, from the remote parts of objects, must necessarily be those which converge; and, in passing through the pupil, they must cross; those from above passing downward, those from below upward, &c., in order to form their impressions or images on the retina; and these images are consequently there inverted.

By removing the sclerotic and choroid coats on the posterior side of an eye, or by employing the eye of an albino animal without that preparation, and placing it in the window-shutter of a dark chamber, the image of an object on the retina is seen to be inverted in every direction,—the rays of light from the upper part of the object forming the lower part of the image,

those from the right proceeding to the left, and vice versa.

On this subject, the following is the experiment made by Scheiner; and it illustrates the safety and the value of experiments made *out* of the body.

If, at the distance of three inches, that is nearer than the limit of distinct vision, the head of a pin be viewed with one eye, it appears large and imperfectly defined, in consequence of the outermost part of the cone of rays entering the pupil from each point of the object, being too divergent to be brought to a focus on the retina.

If, then, a card pierced with a single pin-hole, be interposed between the eye and the head of the pin, the outline of the latter is rendered clear and definite, because the minute hole through which it is seen excludes the outermost rays.—Now, through this hole, the object may be seen by rays passing through the upper part, or the middle, or the lower part of the pupil, according as the card is raised or lowered; and the apparent place of the object may by this means be made to shift. In this case, the object appears to rise when the card is lowered, and to sink when it is raised.

If, instead of one, three minute pin-holes be made close to each other on a vertical line, a clear picture of the object is produced upon

three parts of the retina, and three distinct images are formed.—In this case, it is easy, by closing the pin-holes in succession, to ascertain that the lowest of the three images is caused by the impression made upon the upper part of the retina, and vice versa.

According to some experiments of Magendie, the removal of the aqueous humour, or of the lens, causes the image to occupy a greater space upon the retina.

As rays of light from distant objects are nearly parallel, they converge into a focus nearer the pupil than the more divergent rays from nearer objects. Now, it is well known, that when the eye is capable of distinctly seeing an object at one distance, it does not well distinguish an object at any other. We possess, however, the power of voluntarily and instantaneously altering the focal distance; and this is called the adjustment or accommodation of the eye for distinct vision.

We may, accordingly, distinguish the same object at different distances, which are limited with respect to each individual. Inferior animals discern objects at distances which are extremely variable. Hence birds perceive their prey from immense heights in the air, and still retain it in view until they seize it.

In order to obtain distinct vision in these different circumstances, either, according to the

proximity of objects, those rays alone must be admitted which are nearest to the axis, and which are consequently the least diverging, or the retina must approach or recede, or the lens must move.

The different degrees of contraction and dilation of the pupil, are said by some to present the means of effecting this, because, in viewing a near object, the more divergent rays forming the circumference of the luminous pyramid are separated by the contraction of the pupil and the enlargement of the iris, and those which form the centre of the cone and require only a small refraction to unite on a single point of the retina, are alone admitted; and, on the contrary, in viewing a distant object whence rays, already too convergent, emanate, and which require only a weak refraction to be made to approach the perpendicular, we dilate the pupil to admit more divergent rays, which, united, produce the image of the object.—Now, this is to a certain extent true; but the proper action of the iris is the regulation of the quantity of light admitted; and experiment proves that the pupil may be contracted and dilated without the adjustment of the eye being affected, and consequently that the eye may be adjusted independently of this contractile membrane.

That the action of the muscles of the eye may affect its form, seems to be indicated by the cir-

cumstance that birds, which are most capable of various adjustment, have a particular apparatus, which may appear calculated to facilitate the action of these muscles, viz. a ring of small bony laminæ arranged around the anterior part of the sclerotic coat, more firmly fixed at their anterior extremities, and more loosely posteriorly, where they advance to the convex part of the eye.—But the proper purpose of the muscles of the eye is the general motions of the eye-ball ; they seem little capable either of affecting the bony circle in birds, or of compressing the almost inflexible sclerotic in many animals whose eyes yet possess the power of adjustment ; and, in no case do they seem well calculated to compress it laterally, or to alter its diameter.

That the ciliary processes may act upon the crystalline, seems to be indicated by their extending forward toward the lens, and by the analogy between their structure and that of the iris. Dr. Knox has even described semipellucid fibres extending from the folds between the ciliary processes over the canal of Petit, to the edge of the lens. Birds also which possess this power of adjustment in a great degree, have an additional organ of somewhat similar structure, the marsupium nigrum ; but, in many cases that organ does not appear to reach the lens.

Professor Mile, of Warsaw, has endeavoured to show, that the adjustment of the eye for the

continuous distinct vision of objects contained within certain limits, depends upon the contraction of the iris and the disfraction of the rays of light near the edge of its aperture, in consequence of which there are formed, by a single external luminous point, several foci instead of one, ranged successively in a line of a certain length, so that the object may change its distance within certain limits, and yet one of its foci shall always fall on the bottom of the eye; and that this focal length is inversely as the magnitude of the pupil. He has also endeavoured to show that the adjustment of the eye for the transient distinct vision of objects at different distances, depends upon the flexion of the cornea, or a change in its curvature by the contraction of the iris, which takes place when the eye adjusts itself to see very near objects.

A view similar to the latter, said to have been suggested by Descartes, is adopted by Dr. Knox, who thinks that what has been termed the ciliary ligament is muscular. Mr. Crampton also announces a muscular structure in the eye of the ostrich, which he thinks must alter the convexity of the cornea.

Still, it would appear that no change in the convexity of the cornea produces the effect supposed; for Dr. Young has shown that the eye retains its power of adaptation when immersed

in water, in which the form of the cornea can in no respect influence refraction.

The knowledge obtained by sight, is more varied than that by touch, but it is far less accurate.

Colour is the first and proper object of this sense. We perceive, however, the limits of coloured space, and thereby ascertain shape. Aided also by the experience and the sense of touch, we ultimately judge of the boundaries of objects, by the distribution of colours. Still, whatever ideas relative to superficial forms we acquire by means of sight, are merely so many conclusions from the disposition of the shades with which they are accompanied.

As to the direction of objects, sight communicates, upon the whole, accurate information; the only sources of error, in this case, arising either from reflection or refraction. Rays reflected from a mirror, do not exhibit objects in the direction in which they exist; neither do those which are refracted in passing through media of different densities. Oblique rays coming from an object in water to an eye in air, are deflected toward the horizon, so that it appears higher in the water, as is seen by the lower end of an oar in water. Rays, on the contrary, coming from an object in air, to an eye in water, are bent towards the zenith, so that it appears higher in the air.

As the eye sees only surfaces, it cannot directly inform us of distance; and as distance affects apparent, it cannot inform us of real, magnitude.

Of the magnitude of any object, we judge vaguely from the size of its image on the retina; or more accurately by first considering its distance; and of that, when inconsiderable, we judge by the muscular effort required to observe the object, and, when greater, by observing the intermediate bodies, as well as the distinctness or indistinctness of its outline, minuter parts, and colour. We then determine its real from its apparent size and probable distance.

Of the distance of an object, if its magnitude be known, we judge from our knowledge that the nearer an object is, the larger will be its area on the retina; and the more remote, the less. Of distance, we judge best when two eyes are employed.

As to magnitude and distance, therefore, when judged by the eye, we are liable to continual mistakes, unless aided by the sense of touch. Beyond a certain distance, we have no means of accurate judgment.

Of the motion of a body, we judge by the motion of its image on the retina, and by the variation of the size of the image. When a body is at a considerable distance from us, we can judge of its motion only by the latter of these means.

Upon the circumstances, that the nearest objects have no intermediate ones, and are, ceteris paribus, the largest and brightest, while more remote objects have intermediate ones, encreasing in number with their distance, as well as smaller and duller in aspect, is founded the art of painting.

Many animals can see an object only with one eye at a time. In others, as man, both eyes may be, and generally are, directed to the same object, so as to produce a separate image on each retina. Nevertheless, we see objects single.

Single vision under such circumstances has been ascribed to habit!

The first condition in order that an object forming an image in both eyes, shall appear single, is that the axes of both eyes shall be fixed on the same point of the object, for which purpose the motor nerves and muscles of the eyeball act together, and the rays from all points of the object fall upon corresponding points of the retinæ. When this is not the case, we see double, as is easily shown.

Now here, it isevident, that the upper part of one retina will correspond with the upper part of another, and that the lower part of one retina will correspond with the lower part of another, but that, as the eyes are placed horizontally, it must be the inner side of one retina which corresponds with the outer side of another,

and vice versa. Here, accordingly, commissures, placed horizontally, appear to be employed for the purpose of producing unity of function.

The interior portion of each optic nerve joins its fellow immediately before the crossing of these nerves within the skull; so that these internal fasciculi instead of ascending to the brain, merely establish a connexion and correspondence between the retinæ. This is the commissure of the *sensation* of sight, by which its unity is established; and it appears, accordingly, to be wanting in all animals which cannot see the same object with both eyes.

An interesting question seems to be—why, when one eye is closed, corresponding impressions are conveyed to both sides of the brain, for there exists a totality and unity, not merely of sensation, but of perception, and no imperfect or double sensation and perception, as in touch with one or both hands?

Now, it will be observed that either optic nerve gives fasciculi to both optic tracks—an external fasciculus which goes to the track of the same side, and an internal fasciculus which crosses to the track of the opposite side; so that the simple image thus arising is in reality conveyed to both sides of the brain.

Nature seems even solicitous, that the impressions thus transmitted should reach the

parts in which they terminate, in similar times; and hence the external fasciculus by bending inward to the commissure, becomes as long as the internal or crossing fasciculus.—Nor is this bend and elongation the only expedient for ensuring unity of perception from sight.

The interior portion of each optic track joins its fellow immediately behind the crossing; so that these internal fasciculi, instead of communicating with the eyes, merely establish a connection and correspondence between the cerebral parts in which the optic tracks terminate. This is the commissure of the *perception* of sight, by which its unity is established; and though this commissure may be found in animals in which the eyes are defective, it appears in them to be a mere anomaly or vestigium, like the inferior tubercles in dolphins which have no olfactory nerves, or the mammæ in males who do not give suck.

A third important point in the physiology of the eye, has long puzzled philosophers, viz. how, although objects are inverted upon the retina, we perceive them in their natural position.

According to Berkeley, there is no necessity for touch to remove this error, into which sight would lead us, because, as we connect all our sensations with ourselves, the rectitude of any object is only relative.

This, however, which would be contradicted

by the sense of touch, does not seem to be at all consistent with the manner in which nature usually proceeds. Her means of rendering the visual image perfectly correspondent to every thing that surrounds us are so numerous, and the precision and accuracy of her operations are uniformly so great, that such a doctrine is inadmissible. It is, however, perfectly conformable to the general system of Berkeley, of which the fundamental error was, that it considered the relations of external objects only to sensitive beings.

Blumenbach says, "objects are called inverse in relation only to those which appear erect. Now, since the images of all objects and of our own bodies are painted on the retina, all in their relative situation, their relative situation must correspond as exactly as if they were viewed erect, so that the mind (to which a sensation excited by the image and not the image itself is communicated) is preserved from all danger."

If this, however, were the case, there would, as already observed, exist a perpetual contradiction between the sensations of vision and those of touch.

A more rational argument than this is, that, as by the sense of touch we distinguish impressions made upon any one point of the superficies of the body, in whatever direction an im-

pression may be made, so in whatever direction an impression may be made on the retina, it will be able to distinguish it from others, and, by means of that direction, to refer the rays, wherever they may make their impression, to those precise objects which produce them.

But this argument is also inadmissible, when we consider the different structure of the two organs. The superficies of the body is accessible to impressions in every direction; it has a diversity of experience (if I may be allowed the term) at every point; and it is only by a certain comparison of the difference in the effects of the various impressions which it receives, that it can discriminate them. But the retina is not accessible to impressions in every direction; for no point of the internal superficies of the retina, can be touched by a straight line passing through the pupil, except in one general direction. The retina, therefore, has not that diversity of experience, and those means of comparison, which would enable it, as it were, in a certain sense, to distinguish the difference in the effects of the various impressions which it receives, to discriminate such impressions, or to refer the rays, wherever they may impinge, to those objects which produce them.

It is Dr. Fleming's opinion, that "all this difficulty originates in a misconception of the nature of the retina, and the impressions which

it receives. There is no white screen [as in the experiment alluded to] in the eye, on which the image of an object can be painted. The retina is translucent, and the choroid behind it is black. The retina is not, therefore, acted upon by the reflected rays of the inverted image, as our eye is when looking on the picture formed on the white paper, but by the direct rays from the object passing through its substance. We do not, therefore, see the picture of the object but the object itself. And as we see the object or any part of it, in the direction of those rays which proceed from it, and which produce the sensation, it follows, that the eye really sees objects in their natural and relative situation."

Mr. Mayo's view is similar. He says "the rays from the object towards which the eye is turned, are represented as reversed upon the retina. This fact which is easily shown in the eye of a dead animal, is commonly considered as a defect in the mechanism of sight requiring compensation. So far, however, is this from being true, that the inversion of the picture is the only means by which correct vision could have been attained. For the upper part of the retina is that which alone, by the law of vision above stated, can see downwards [the lower, upward; the inner, outwards; and the outer, inwards]. The rays from the lower part of the object must therefore be brought to the upper

part of the retina, as the only part at which they they can excite a just impression of the direction of the point from whence they have come."

Now this idea "that we see the object in the direction of the rays which proceed from it," as expressed by Dr. Fleming, or "that the upper part of the retina sees downward," and vice versa, as expressed by Mr. Mayo, is surely a strange mistake. It supposes the eye to be active, and, in its function, as it were, to follow the ray toward the object; whereas the eye is the mere recipient of impressions, and in itself possesses no such mode of external reference.

Mr. Mayo adds, referring to a diagram, "Excite the point A of the retina any how, so as to produce sensation of colours, they will be projected in the line A B:"—that is, colours will be projected from the retina toward the external object; for A is here on the retina, and B externally.—This is strange reasoning. How can the retina project colours? Where does it get them for this projection?—An answer to the last of these questions will show where the difficulty lies.

Still, however, there appears to be a very simple mode adopted by nature, by means of the curves of the optic tracks, of again reverting the optic image both horizontally and vertically.

For the purpose of reverting the image horizontally, it will be observed, that the optic nerve or track, in crossing from the commissure, that is from the median line of the brain to the outer side of the cerebral peduncle, presents an equivalent to a curve of a quarter circle,—and in turning inward (I speak not now of the bend upward) to join the tubercle, it presents another, —and, if thence it be considered as passing forward toward the cerebrum, it is evident that its external fibres become internal, and its internal fibres external.—Thus, whatever impression it conveys, must be reverted horizontally.

For the purpose of reverting the image vertically, it will be observed that the optic track bends (not only outward, backward, inward, and forward, or in the horizontal direction) but also backward, upward, and forward, or in the vertical direction; so that its inferior fibres must become superior, and its superior fibres inferior. —Thus, whatever impression it conveys must be reverted vertically.

CHAPTER VI.

HEARING.

There are points in which the ear of various animals is superior to that of man; but that the organization of the latter, as observed by Carus, is best adapted to distinguish the most various sounds and modulations of tone (as well, he should have said, as all articulate sounds) may be concluded from the extent of the capability of moulding the voice—the correspondent faculty, which does not exist in the same degree in any other species of animal.

The ear is usually divided into the inner, the middle, and the outer ear. An admirable specimen of some portion of its minute anatomy is to be found in Sir Anthony Carlisle's paper on the physiology of the stapes, in the Philosophical Transactions, for 1805. It will always be regretted by the friends of science that, in the publications of the Royal Society, such papers gave way to the fabrications and nonsense of Sir Everard Home.

To understand the uses of the parts of the ear, it is necessary briefly to consider the nature of sound.

Sound is produced by the motion of the parts of a body, as by a blow, or by the friction of one body against another.

Air is the only substance which seems constantly to exist between sounding bodies and the ear. Hence we have reason to conclude, that it is the means of conveying sonorous vibration.

A bell suspended in the vacuum of an air-pump gives no sound, though its parts are evidently thrown into vibratory motions. As the air receives admission, the sound becomes more distinct. If it be condensed, the sound is louder than in air of the usual density.—The vibrations of the air are moreover evidenced by those of the dust, smoke, and light particles which float in it.

Through this medium, sound is propagated in vast undulations, like those formed by a stone thrown into water, but which spread spherically in every direction. Its intensity diminishes in the ratio of the square of the distance; it is lost by passing from one medium to another; and it may be reflected from the surface of bodies.

Now, in regard to what has just been said, one part of the physiology of the ear has long been understood; namely, that the external ear, or rather its cartilaginous part called pinna, col-

lects the vibrations of the air, and transmits them through the external auditory tube, technically called the meatus externus, to the membrane of the drum or membrana tympani. This is evident from weak and timid animals having the external ear and auditory tube directed backward, toward their pursuers, while predacious animals have these parts directed forward, toward the animals they are pursuing.

Perhaps the pinna may also by vibrations encrease the strength and intensity of sounds.

It seems also probable, that, by this part of the ear alone, we distinguish the direction of sounds. Ascending vibrations may be distinguished by the upper part of the helix and concha ; by the latter reflected directly downward, and by the former, along the fossa navicularis, to the meatus : descending vibrations may be distinguished by the tragus, antitragus, and inferior part of the concha, and reflected from their obliquity in a direct line to the meatus : vibrations from before may be distinguished by the posterior part of the concha, whence they also are almost directly reflected : and vibrations from behind, impinging upon the tragus and fore-part of the helix, may, by the former, be carried directly, and by the latter, along the fossa navicularis, to the same parts.

It appears to be a confirmation of the preceding opinion, of the external ear being the sole

organ by which we judge of the direction of sounds, that animals with cropped ears are generally less sensible of the direction of sound than those which possess them entire.

It is worth remarking that the posterior and superior situation of the pinna of the external ear, exactly corresponds to the situation of the semicircular canals of the internal; and it will be found, that as the former receives the general and larger, the latter receives the particular and minuter motions of sound.

There can be no doubt that we receive two impressions of every sound, though we perceive only one; for we distinguish a sound most easily by the ear which is nearest it, and when we are uncertain of the direction of a sound and wish to determine it, we employ both ears, in order to compare the intensity of the two impressions.

The tube of the ear, called external auditory tube, partly bony, partly cartilaginous, extends inward and forward from the external ear, in a curve somewhat resembling an italic *ſ*, and terminates on the membrane of the drum.

The middle ear is also called the drum or tympanum. Its inner side is the outer wall of the inner ear; and its outer side, the membrane of the drum. It opens before into the fauces by a tube, called the eustachian; and it is continued backward into the cells of the bony protuberance behind the external ear.

The drum contains a chain of bones called malleus, incus and stapes, which extend in the order now mentioned from the membrane of the drum to the membrane extending over the oval hole or fenestra leading to the vestibule, semicircular canals, and vestibular half of the spiral cone. These are slightly moved by four small muscles called the tensor of the drum, the anterior and posterior of the malleus, and the stapedius, giving various tensities and directions to the membranes.

Now, very strong sounds communicate motion to bodies of every kind. Even less sounds, however, are not merely communicated to the external air, but to all such bodies as, if struck, would emit a sound similar to the original one, or, in other words, would produce similar vibrations. —This is a consequence of the vibrations of the air being performed in times similar to those of the sounding body.

All elastic membranes, says M. Savart, whatever may be their state, vibrate and transmit sound in unison with sounding bodies near to them; and this is important in relation to the physiology of the ear, which presents several membranes.

It seems probable, however, that, while the vibrations received and distinguished by the external ear, pass along the external tube, they by acting upon its finely distributed nerves, which

are branches of the facial nerve, excite into action those other branches of the same nerve which supply the tympanic muscles. In consequence of this, these muscles instantly give that tension and direction to the membrane of the drum, which is necessary for the reception of the impinging vibrations; and whatever actions are thus given to the bones of the ear, are propagated to the chorda tympani, a branch of the same nerve.

That it is by affecting the external tube that the muscles are excited, I think much more probable than the hypothesis of Caldani, who supposed that these muscles are excited in consequence of some action on the chorda tympani. Before the chorda tympani could be affected, the vibrations must have already impinged upon the membrane, and the subsequent action of the muscles upon it would be useless.

That these muscles affect the tension, relaxation, and direction of the membrane, may be demonstrated by experiment; and in the same manner it may be shown that by means of the stapes, they affect the membrane of the oval hole, and consequently the whole internal ear. If in an ear which has been immersed in spirit, the superior semicircular canal be opened, and the ossicles of the drum be then moved by means of their muscles, and this is very evident when the stapedius is acted upon, the spirit in

the canal will be seen to rise or fall with every action of the muscles. This I, many years ago, demonstrated to Dr. Barclay, while showing him the use of the stapedius in projecting the membrane of the drum outward.

There can be no doubt, therefore, that these muscles give such tension or relaxation of the internal ear as raises or lowers the tone of its action to any part of the scale of sounds; while all the various inclinations which they give to the membrane of the drum and to the base of the stapes, must also give various general directions to the impulses which they transmit.

Now, to receive these vibrations, the membrane of the drum is admirably adapted, being in general slightly concave on its outer side, so that vibrations which tend in any particular direction, will readily glide from any other side, and impinge upon that side of the membrane which is most at right angles, or opposed to their line of percussion, and correspondingly affect the ossicles of the ear; and this I conceive to be the use of the various directions assumed by the membrane.

The membrane, then, having, as above described, assumed a proper degree of tension and inclination, the vibrations will pass in two directions across the drum, namely, by the chain of bones, to the membrane of the oval hole, and, by the air of the drum, to the membrane of the

round hole, the posterior and external aspect of which being, as remarked by Scarpa, concave, is, like the membrane of the drum, adapted to receive the differently directed vibrations.

To understand the functions of this part of the ear, it must be observed that undulations from sonorous impulses pass least quickly through aeriform fluids; more quickly through liquids; and most quickly through solids: namely, respectively, at the rate of 1142, 4900, and 18000, feet per second; and that the velocity of sound is also the same whether high or low.

The eustachian tube or passage to the fauces, permits the renewal of the air in the drum, maintains the equilibrium between the external and internal air, and prevents irregular pressure either on the outer or inner side of the membrane.

Thus, we arrive at the internal ear, a rational physiology of which is by far the most difficult.

This is the most essential part of the ear, as it exists in animals which present no external apparatus; and its principal characteristic is some part or parts of extreme solidity, as, even among mollusca, the bony shell of the ear of the sepia officinalis, and those in the ear of fishes, which diminish as we ascend among animals only because they receive a substitute in the hard walls of the auditory cavity, as in those furnished in

quadrupeds by the petrous part of the temporal bone. In all cases, it seems necessary to the sensation of sonorous vibrations, that the nerves of hearing should be capable of being compressed against solid matter; and accordingly, in inferior animals, this lies within the nerves which are lapped around it, and in superior animals, it in various complex forms, envelopes the nerves.

Dr. Young, who had much of the requisite knowledge and the courage to think for himself, has written about the physiology of the internal ear—without success, as will be seen in the sequel. Others have not even attempted it.

The apparatus of hearing, says Magendie, "is very complex; and I shall not insist upon anatomical details, from which no advantage could arise; as the uses of the different parts that constitute this sense are but little understood"—"on ignore absolument la part que prend à l'audition chacune des parties de l'oreille interne."

Of the vestibule, spiral cone, and semicircular canals, Mr. Mayo says, "A particular description would be superfluous, as the specific advantages resulting from their shape is unknown."

"In examining the organ of this sense," says Alison, "we see indications of much contrivance, the uses of which are not understood; and therefore it is to no purpose to enlarge on them."

"There are many *singularly shaped* canals," says Dr. Bostock, "excavated in the temporal bone, which *communicate with the ear ;* but of the specific use of these parts, it may be said that nothing is certainly known."

"It is probable," says Richerand, "that the various forms of the internal ear have *something* to do with the diversity of sounds !"

I quote these passages to show that the reader ought graciously to receive any rational attempt at explaining the functions of this organ, which are next in difficulty to those of the brain.

Previously, however, to attempting this, it is necessary to observe, that sounds may exist in various modes.

Sonorous vibrations may be so produced and impelled as to give particular forms of sound. This is distinctly done by the human mouth, and by the apertures of tubes of particular construction. The forms are, in these cases, denominated vowels ; and every musical instrument produces one of them, however indistinctly. This affords one of the bases of spoken language.

Sounds may, moreover, be distinct, related if not coexistent, or successive ; and this indeed is the division which is made of them, however vaguely, in the present theory of music, where distinct sounds retain that name, coexistent sounds are termed concordant or discordant,

and distinct or coexistent successive sounds are termed melody and harmony.

Now, in order to obtain a consistent physiology of the internal ear, it seems rational to look, in this complex organ, for these subordinate organs, namely an organ for the forms of sound; an organ for the impression of distinct sounds; an organ for the impression of related or coexistent sounds, or of concords and discords; and an organ for the impression of distinct or coexistent successive sounds, or of melody and harmony.

Very curiously the labyrinth or internal ear presents a corresponding arrangement of parts, consisting of the spherical sac or sacculus sphericus of the vestibule, the semicircular canals, the spiral cone or cochlea, and the common recipient or alveus communis canalium semicircularium; and in these parts, we may rationally look for an organ of each of the modes of the existence of sound.

The filaments of the auditory nerve supply the spherical sac, semicircular canals, spiral cone, and common recipient.

Now, the vestibule is a cavity of somewhat spheroidal form, placed internally to the drum, and between the semircular canals behind and the spiral cone before. It is slightly divided into two unequal portions. It communicates with the drum by the oval hole, which is covered

by a membrane, and receives the base of the stapes; and it presents various openings which have already been mentioned.

The spherical sac of the vestibule receives a branch of the auditory nerve which is remarkable for its radiation in every direction. Nothing could be better adapted for the reception of the forms of sound, which occur most generally in nature, and constitute a basis of language. It is, accordingly, the part found even among the lowest animals, as in the sepiæ among mollusca, and in them it contains the most considerable of the bony concretions.

Solid bodies suspended in a liquid, must evidently encrease the intensity of sonorous vibrations; and when such encrease of intensity takes place in actual contact with the nerve of hearing, by its fibrils being wrapped around the solid body, the utility of the latter must be evident.

Before proceeding to more complex parts, we must enter into some considerations respecting the nature of sound, and these of a minuter description.

When a sonorous body is struck, its integrant particles appear to be displaced and to oscillate. Indeed, all sounding bodies evidently vibrate; the vibration of the larger ones being even sensible to the eye, and very distinct to the touch.

In a bell that has been struck, this tremulous motion of particles may be felt by the hand.

As sound is caused by the vibratory motion of the atoms of bodies, it is modified in exact conformity with their internal structure.

The *quality* or *timbre of sound* depends on this.

It appears to me, that it is especially upon a *more minute direction of the vibrating particles* that sound depends; that upon difference of that direction, difference of sound depends (which accounts for various sounds being propagated without being confounded); and that, upon the degree or extent of that direction, its degrees of strength depend.

Sound seems to me to depend on the formation of minute vacua within bodies, or the media which transmit it, and upon the collapse of the particles forming the sides of these vacua.

It may here be observed that the velocity of sound is slightly altered by wind, of which the velocity is, however, far inferior to that of sound. This fact clearly shows that, in this case, two very different sorts of motion take place in the air, and that the vibrations of sound are very different from the motions of its masses.

Now it appears to me, that the *direction of these vibrations*, must uniformly be of a circular kind.

In order to illustrate this, I may choose, as

an example, the vibrations produced by a sonorous metallic plate. — Suppose this plate to be held by one edge, as the leaf of a book is attached to the back (for all sounding bodies must have one point at least more fixed than others), and that its loose or free edge is struck laterally, it is evident that as one edge is fixed, the other must move upon it as an axis — must move, in some degree from side to side, and that, however small its vibrations, they must form segments of a circle, the radius of which is equal to the width of the plate. Hence then, the minute intervals which it leaves at every point of these segments, must be circularly arranged, or have a circular direction.

Nor does this take place merely in a sonorous plate; for upon this principle must all other sonorous bodies vibrate. In a musical string, the two ends are fixed, and the centre vibrates around both.

We shall presently see how applicable these facts are to the illustration of phenomena of hearing. But there are other circumstances as to sound which may first be noticed.

On the time between two successive vibrations depends the *musical degree of sound;* the time being greater in grave sounds, and less high ones.

The continuance of these vibrations is accord-

ing to the greater or less elasticity, and the thickness or thinness of the sounding body.

Musical sounds, then, consist of regular vibrations, which take place in bodies having a uniform texture and figure.

When any such sonorous body is struck, there is first and chiefly heard a distinct sound called the fundamental, tonic, or key note; but, with attention, others may be distinguished, namely the third or mediant, and the 5th or dominant, as well as the octave.

A sound composed of double the number of vibrations of another, is said to be its octave, because the intermediate sounds between them are seven in number, namely ut or do, re, mi, fa, sol, la, si, which constitute the diatonic scale or gamut; and this octave is produced by shortening the string one half, or by reducing it one half in thickness, or by rendering it more tense.

The *intensity* or *loudness of sound* depends on the extent of the vibrations. Large vibrations produce strong or loud sounds; small ones, the reverse.

Now, as I have shown that all sonorous vibrations and intervals must possess a semicircular arrangement or direction, whatever their general direction may be; and as it is evident, that particular arrangements or directions of these vibrations are necessary to the existence

of particular sounds, it follows, that, in order to make peculiar and corresponding impressions, these vibrations should, within the ear, pass in corresponding directions; and, for this purpose, an organ somewhat complex, consisting of channels in different directions, and these circular, must exist.

This precisely is what we find in the semicircular canals.

These canals, which first appear in fishes, and are situated behind the vestibule, are three cylindrical tubes bent in a semicircular form, two of which are disposed vertically, and the third horizontally; and all of which terminate by their extremities in the vestibule.

The posterior canal is the largest. It commences by an aperture, which is common to it with the superior canal, and which is situated at the innermost part of the vestibule, exactly opposite to the oval hole; it bends backward, outward, and forward, but mainly downward; and it terminates by its enlarged elliptical aperture or ampulla at the very lowest exterior part of the vestibule.—From its general course, it may well be called the Descending Canal.

The external canal is the smallest. It commences by a separate aperture immediately behind and a little higher than the beginning of the preceding canal, and therefore also at the innermost part of the vestibule, and nearly op-

posite the oval hole; bends likewise backward, outward and forward, but does not descend; and terminates by its enlarged elliptical aperture or ampulla, at the middle or rather upper exterior and posterior part of the vestibule, between the oval hole and the termination of the superior canal.—From its general course, it is properly called the Horizontal or intermediate Canal.

The superior canal is of intermediate size. It commences by an aperture which is common to it with the posterior canal, at the innermost part of the vestibule and exactly opposite the oval hole; it bends upward and outward; and it terminates at the upper, exterior and anterior part of the vestibule.—From its general course, it may well be called the Ascending Canal.

The bony walls of these canals are extremely dense; and their internal surface is smooth and polished.

These cavities are not merely lined by a periosteum or bone-covering membrane, filled by a transparent liquid, but they contain other membranes having nearly the shape of the containing parts. These form, with the second sac of the vestibule to be afterwards mentioned, one complicated and closed cavity, which also contains a transparent liquid. While, therefore, the liquid without this membranous labyrinth preserves it from contact with the walls of the

bony cavity, that which is within the labyrinth keeps it patent and permits the expansion of the nerve.

Each semicircular canal, then, may be said to receive from this sac of the vestibule a membranous tube, in the termination of which it expands into an ampulla or enlargement, the whole being filled with water, and each ampulla having a pencil of nervous fibrils projecting within it.

Having reached the vestibule, it is therefore evident, that the vibrations will pass through and affect the nerves distributed in that particular semicircular canal which possesses the direction corresponding with that peculiar movement of particles of which the vibration consists, and upon which the existence of the particular sound depends; and that, therefore, the Semicircular Canals constitute the organ on which Distinct Sounds are impressed.

This theory is supported by the distribution of the branches of the auditory nerve upon the membranous semicircular canals; for the sentient extremities of none of these nerves can be directly impressed in the vestibule, their sides only being turned to it; but, as all of them enter the semicircular canals, the vibrations must pass into the canals in the direction which is opposite to that of the nerves, and in some measure through these canals, before the extremities of the nervous pencils occupying

the elliptical enlargements or ampullæ of the canals, can possibly be impressed.

This shows the error in Dr. Young's notion, that the semicircular canals assist "in the estimation of the acuteness or pitch of the sound, by receiving its impression at their opposite ends, and occasioning a recurrence of similar effects at different points of their length, according to the different character of the sound."

Vibrations cannot enter the elliptical ends of the canals: first because they are every one placed laterally in relation to the oval hole, and therefore disadvantageously for the reception of impressions; and secondly because they are occupied by the entrance of the expanding auditory nerve.

On the contrary, the other extremities of the canals are exactly opposite to the oval hole, and are unoccupied by the nerves. Being placed also horizontally and side by side, these holes accurately correspond to the oval hole which leads to them — a fact not hitherto observed.

From all this, it follows, that by examining the circumference of these canals in any animal, we may perhaps ascertain what sounds it can distinguish. Too strong sounds will probably fall on the external; too weak ones, on the central or internal sides of the canals; and thus both will be rendered indistinct. In man, these canals are nearly equal in circumference; and

this is consistent with the rest of his structure. In birds and beasts of prey, which are calculated to distinguish the minutest sounds, some of them are, consistently with what I have just stated, always of proportionally smaller size, e. g. in the owl. Hence some quadrupeds and birds perceive sounds which are inaudible to us.

Moreover, as one of these canals terminates below; another intermediately; and a third above; it seems not improbable that this has a relation to the musical degree of sound—its gravity, intermediate state, and height.

That the gravity and height of sounds are connected with their actual descent and ascent, is at least illustrated by the fact, that when we call to a person who is far below us, or at the bottom of a pit, we naturally do so in a grave, full and hollow tone, and when we call to one who is much above us, in the open air, we as naturally do so in a high, slender or shrill tone.

This connection of the gravity and height of sounds with their actual descent and ascent is further illustrated by the curious circumstance that mountaineers speak in a higher tone of voice than lowlanders do. The difference, in this respect, between the Scottish and English is sufficiently evident. So also, as Dr. Hancock has just informed me, the Makoosis, residing on a branch of the Parime mountains, speak in a high or

sharp tone, while the Warrows, residing on the low and muddy shores near the mouth of the Orinoco, speak in a grave and guttural tone.

Now, it has been stated, that when any sonorous body is struck, we hear chiefly three sounds, the fundamental, tonic or key note, the third or mediant, and the fifth or dominant. These respectively are grave, intermediate, and high. It seems, therefore, not improbable, that to these the relative direction and the position of the greater apertures of the three canals are adapted.

As these three apertures are fixed and immovable, so is the relative distance of the tonic, mediant and dominant; and as the whole of these last may be raised, or lowered, in the same relation, to any part of the musical scale, precisely in the same manner may be varied the adaptation of the three apertures of the canals, because the pitch of the whole apparatus may be raised, or lowered by the action of the tympanic muscles at once stretching or relaxing the membrane of the drum and that of the oval hole of the labyrinth.

To those who understand the relations of these canals and corresponding sounds, and the means, just described, by which the whole of the former may be raised or lowered, maintaining in the ear a perpetual play and adaptation, like that of the iris, &c. in the eye, it is scarcely pos-

sible to present for contemplation anything more interesting than this.

We proceed now to consider the next portion of the ear.

The spiral cone or cochlea is situated before the vestibule, and somewhat resembles a spiral univalve shell. It first appears among reptiles, in the lizards, and especially in the crocodile, in a somewhat rudimental state.

In man, it presents an axis or central pillar, called modiolus, which is directed nearly horizontally forward and outward, and which is of conical form, its base being depressed to receive a portion of the auditory nerve, its surface being spirally marked by a double groove, and presenting numerous holes for the passage of nerves, and its apex having in it a small cavity called infundibulum.

Around this axis, a hollow cone is wound spirally, forming two turns and a half, and gradually diminishing toward the infundibulum of the axis.

This hollow cone is then divided in the middle throughout its length by a thin spiral partition, which is composed of two distinct parts, —a spiral bony plate which adheres by one edge to the axis precisely like the thread or worm of a screw, and like it has a free edge, which stretches about half way across the winding cone, being broader toward the base of the

spiral cone, consisting of two thinner plates, between which are numerous canals for nerves, and ending upon the axis toward the middle of the second turn,—and a spiral membranous plate called zona mollis which stretches from the edge of the preceding to the middle of the outer wall of the hollow cone, but extends alone, through the last turn, to the apex, where it becomes deficient, leaving a small round aperture, by which the two half cones thus formed communicate.

These two half cones are called the scalæ of the cochlea, of which one, the internal, is, at its base, separated from the cavity of the drum only by the membrane of the round hole, and the other, the external, opens into the cavity of the vestibule, and is consequently separated from the drum only by the membrane of the oval hole, and the base of the stapes.

The membrane of the vestibule passes into the spiral cone by the opening of the external half cone, lines that half cone, and descends through the internal one to the round hole, being similarly filled with liquid.

In the spiral cone, the filaments of the auditory nerve form a zone, marked by plexiform striæ, which pass between the two plates of the membranous partition or zona mollis.

Now, the air of the drum, and the solid chain of bones, must convey vibrations in different times to the two half cones; and this is illustrated

by the circumstance that when a loud sound is produced at one extremity of a series of metallic rods, an ear at the other extremity hears two sounds, the first conveyed along the metal, the second through the air. As, then, these vibrations must be conveyed in different times to the half cones, it is evident that a portion of one series of sounds will reach the tympanic half cone at the same moment that a portion of the accompanying series reaches the vestibular. Hence different portions of the two series of vibrations must, at the same time, exist within the spiral cone, one, at the same instant, impressing the internal, the other, the external side of the same nerves distributed upon the membranous partition. Thus, these nerves must be affected by the consonance or dissonance of the two coexistent series, and the spiral cone must constitute the organ of related sounds—the organ by which we judge of the relation between immediately preceding and succeeding sounds, or of the concordance or discordance between them.

It may be some confirmation of this theory, that singing birds have a larger round hole and internal cavity than those which merely chirp or scream, though, in all, this portion of the organ is very imperfect.

This is a remarkable organ, of which I could not have foreseen the existence or use by any previous knowledge of the nature of sound; but

it nevertheless seems indispensable to a perception of the relations of sounds. In seeing, a complete object or scene is before us; and it easily takes its place in the memory. In hearing, which depends on incessant motion, only one atom of an extensive whole exists at one time, and therefore to discern the relations of the parts of this evanescent movement, an organ like the spiral cone was indispensable.

In several mammalia, the spiral cone makes even three turns and a half; and it probably confers on them a corresponding superiority over man in this respect. At this, however, we need not be surprised; for though the ear of man is probably superior to that of other animals as a whole, yet, as observed by Carus, it is evidently inferior to that of some quadrupeds in the size and mobility in the external ear, in the extent of the drum, in the strength of the apparatus affecting the tension of the membrane of the drum, in the greater size of the parts of the labyrinth and its more complete detachment, in the greater bulk of the auditory compared with other nerves, &c.

We proceed now to consider the last part of the ear.

In music, melody is a succession of single sounds, and harmony is a succession of coexistent sounds. The art of music, therefore, is that which places sounds in such arrange-

ment as to produce expressive melody and harmony.

There should exist therefore a portion of the labyrinth through which every sound, whether single or complex, must pass in succession, and impress the same nerve so distributed, that no vibration can escape it; in other words, an organ of melody and harmony.

Now, the vestibule, as already said, contains two very delicate membranous bags. One of these, the spherical sac, has been already mentioned: the other, the common recipient or alveus communis, is connected with the semicircular canals.

As all the canals, the organs of distinct sounds, terminate in the recipient of the vestibule,—the nerve radiating in it must be impressed both by successive distinct or simple sounds, and by successive concords or discords, and the common recipient therefore must constitute the organ of melody and harmony.

It is remarkable that the common recipient not only directly communicates with the semicircular canals, but is supplied by the same branch of the auditory nerve, while the spherical sac and the spiral cone have distinct branches.

As this organ more than any other, approaches the brain in complexity and in the difficulty of its physiology, I have thus far occupied with it the reader's attention.

CHAPTER VII.

SENSE OF HEAT.

The accuracy of touch has sometimes been called in question, because we do not judge precisely of the temperature of bodies. Form and temperature, however, appear to be the objects of different senses; for when the sensibility of the skin to touch has been lost, it has remained sensible to heat, and vice versa; and even in health, sensibility to touch and to temperature are not in proportion to each other, either in different persons, or in different parts of the same person.

To the sense of heat, which is properly a passive sense, contact is necessary; but it may be the contact of the intervening atmosphere. The especial characteristic of the sense of heat as distinct from touch, is that our motion is not necessary to it.

This sense seems to be dependent on nerves belonging to the vital system, for every variation in the condition of that system seems to affect

it. It seems probable that it is upon the same nerves that pain is dependent; for, in external injuries at least, heat seems always to accompany pain,—the increase of external heat increases pain, — and the reduction of heat diminishes or entirely removes pain. Hence when parts are destroyed by cold, no pain is caused, so long at least as cold continues; and, on the contrary, when hot sealing wax is dropped on the skin, the pain is instant and intense.

As touch is the fundamental sense, and that of which all the rest are mere modifications, it is worthy of notice that it is possessed by the fœtus in utero, as the latter moves in consequence of pressure. The fœtus, however, is also sensible to change of temperature, as local cold produces the same effect. This last sense, then, seems to have nearly the same relation to the vital system that touch has to the mental. Thus, the bases of all our sensations of both kinds are laid in utero.

CHAPTER VIII.

FUNCTION OF SENSATION GENERALLY.

So close is the analogy in the functions of all the organs of sense, that tasting, smelling, seeing and hearing seem merely to be different modifications of touch.

Tasting resembles it in this, that the variously-formed sapid particles of bodies touch the organ by the intervention or aid of some liquid. Smelling resembles it in this, that the variously-formed odorous particles of bodies touch the organ by the intervention or aid of air. Seeing resembles it in this, that the variously-formed particles of bodies reflect upon it, or touch it, by the intervention of luminous rays. Hearing resembles it in this, that the variously-formed particles of bodies impinge against it, or touch it, by the intervention of sonorous vibrations.

Thus all the causes of sensation are ultimately dependent on the forms of matter, and are mere modifications of touch.

In the more perfect animals, indeed, each of these general modifications is the object of a particular organ, and is transmitted to the brain by a particular nerve of impression. But that all sensation is thus a mere modification of touch is proved by comparative anatomy; for the horns of the snail and the whole superficies of many animals, are at once their organ of touch, taste, smell, seeing and hearing; or, in other words, are susceptible of impressions from all those forms and actions of matter which, in the more perfect animals, impress distinct organs.

Thus sensation seems to be entirely dependent on touch, which, in the other senses is only modified, so that one receives one kind of it, and another another. The tongue, therefore, is touched by means of liquids, the nose by means of air, the ear by aëriform vibrations, and the eye by light.

That sensation belongs entirely to the organs of sense, is clearly proved by its existence in all the animals which have no common sensorium, and in which, consequently, perception is wanting.

Nor is this, in the slightest degree, invalidated by patients seeming to have sensation even in amputated extremities; because, in such cases, the sensation, if it can be said to exist, merely exists at the extreme surface of the remaining

portion. But the sensation in this case may properly be termed a deception or mistake. "The pain or sensation," says Dr. Darwin, "which formerly had arisen in the foot or toes, and been propagated along the nerves to the central part of the sensorium, was at the same time accompanied with a visible idea of the shape and place, and with a tangible idea of the solidity of the affected limb: now when these nerves are afterwards affected by any injury done to the remaining stump with a similar degree or kind of pain, the ideas of the shape, place, or solidity of the lost limb, return by association; as these ideas belong to the organs of sight and touch, on which they were first excited." Thus the perceptions arising from the stump of an amputated limb depend greatly on memory and association, which reproduce them, when, through the same nerves, a portion of the brain repeats the action formerly occasioned by impression upon their extremities.

Muscular irritability, when a nerve is tied or cut, is a beautiful illustration of sensation existing without perception; and the intestines, in their peristaltic motion, afford a similar example even in health. It is exactly in the same way that several animals possessing a brain retain sensation (in this case termed irritability) unimpaired, long after the brain is removed; and

that others evince sensation, which at no time have any brain.

The whole of the common error upon this subject, arises from not distinguishing between sensation and perception; the latter of which can exist only in a common sensorium, and is so far different from the former.

CHAPTER IX.

DIFFERENT EFFECT OF THE FUNCTION OF EACH ORGAN OF SENSE UPON THE BRAIN.

Although we have hitherto known much as to the various functions of the eye, ear, nose and mouth, yet no one seems to have enquired, whether an effect totally distinct in its character was not produced by the action of each of these parts communicated to the brain,—whether some of these organs led not to emotions, and others to passions,—and whether some of them were not subservient to vital, and others to intellectual purposes.

Now, from the three more important senses, it appears to me that we derive impressions differing not only in their nature, but in their effects.

From the peculiar objects of touch, we in reality derive chiefly ideas; from those of sight, chiefly emotions; and from those of hearing, chiefly desires or aversions.

In illustration of this, as of all simple truths, there exist many popular notions, as of the pe-

culiar accuracy of touch, the superficial pleasure derived from colours, and the deeper affections from music.

An idea being the mental image of an external object, &c.—emotion being pleasure or pain superadded to this idea,—and desire or aversion implying a deeper interest superadded to this emotion,—a little reflection will show in what way these respectively are generated by the senses to which I have ascribed them.

I. The accuracy of touch seems to be proportioned to its limitation, and hence it can create in the mind chiefly ideas, or give us, directly at least, only notions of the thing's existence and of its parts.

A little consideration of the simpler and more elementary objects of touch (for it is evidently these which we must here contemplate) will render this clear. That an object is triangular, quadrangular, or has any number of sides, though it always gives the most precise, distinct and impressive idea to the mind, never gives an emotion of pleasure or pain, or a passion of desire or aversion. Its existence seems to us to belong to itself—to be a thing apart from us: it neither possesses a relation to, nor exerts any action upon, us: we cannot therefore wonder that it excites in us neither emotion nor passion.

II. The vagueness of sight is compensated by its extension. The state of the atmosphere con-

stituting light, though it show only the superficies of each body, displays the relations of many, both to each other and to the observer, and these relations being necessarily either agreeable or disagreeable, add pleasure or pain to the idea which they involve, or constitute an emotion.

Let any one turn his eyes upon a flower-bed, or a mass of variegated foliage; and even without there being any distinct idea, and still less of apparent reason for it, the emotion of pleasure or of pain, however slight, will be irresistible. This will not, however, excite the passion of desire or aversion—except indeed indirectly and by means of association. Such objects relate to, but do not act upon, us; and even from that relation, we easily withdraw ourselves by closing the eyelids, or averting the head, or passing by. Colours, therefore, seem to form the language of emotion.

III. The atmospheric motions which constitute sound are the reports, as it were, not merely of the relations of bodies to each other, but of their actions upon each other, and upon the organs of the hearer. Instead of being the passive subjects of his sense, like forms in touch, he is the subject of their action, and, as this action affects him either pleasureably or painfully, it creates desire or aversion.

Thus it is that musical sounds, however

vaguely they may excite ideas, call up the passions; and under their almost magic power, tears burst from the eyes, or the skin is paled and corrugated, and the hair erected, or the eyebrows are knit and the muscles are braced, and grief, or fear, or hatred agitate the frame. To sounds, moreover, which thus not only relate to, but act upon, us, the ear cannot close itself, and time is required to withdraw us, if we were willing. Thus the nature both of the organ and of the objects which impress it, encreases their power over the mind. Hence music is the language of passion.

Carus has some confused notions of the nature and relations of the senses, but he hits on one of the truths connected with this subject viz. that hearing is the sense of the system of motion. Magendie observes that music and even noise excites to motion. Music accordingly has created dancing.

Now the nerves of touch in general pass toward the anterior part of the brain; the nerves of sight, toward the middle part of the brain; the nerves of hearing, toward the posterior part of the brain; and the nerves of motion descend from the cerebel.

Hence, the functions of these parts also of the brain would be indicated, if we had no other guide, as relating to ideas, emotions, and passions respectively.

IV. & V. The nose and mouth are as evidently connected with vital purposes, as the eye and ear with intellectual ones; and a little consideration will show that they are calculated for the excitement of emotion and passion of that inferior order.

As to the nose, it will, as soon as suggested, be evident, that in regard to alimentary substances, it can procure only the preliminary pleasure or pain, and not the final gratification of desire. It is the organ, therefore, of vital emotion, as the eye is of intellectual emotion; and it is remarkable that its nerves, like those of the eyes, pass toward the middle part of the brain.

As to the mouth, it will also, as soon as suggested, be evident, that, in regard to alimentary substances, it does procure the final gratifications of desire. It is the organ, therefore, of vital passion or propensity, as the ear is of intellectual passion; and it is likewise remarkable, that its nerves, like those of the ear, pass toward the posterior part of the brain.

Thus, the eye and nose are associated in emotions, though these emotions are of different kinds; nor do they agree only in this general approximation of purpose and passage of their nerves, the seat of smell internally is placed precisely between the two seats of vision, and externally the lachrymal ducts, maintaining the

connexion, pass from the inner angles of the eyes into the nose.

Thus, too, the ear and mouth are associated in passions, though those passions are of different kinds; nor do they likewise agree only in this general approximation of purpose and passage of their nerves, the seat of taste internally is placed within the curvature of the under jaw, at the two extremities of which, and external to taste, as sight is to smell, are the two seats of hearing, the jaw ending where the ear begins, while at the same time the eustachian tubes, maintaining the connexion, pass from the ear toward the mouth.

But while the intellectual organs, the eye and the ear, which resemble in being double, also hold a considerable distance from each other, the two vital organs, the nose and the mouth, which resemble in being united or single, also approximate to each other gradually, opening internally into the same cavity, and terminating externally near each other upon the face.

Nor is this all: so necessary is the approximation and accompaniment of smell and taste to animal purposes, that though the nose—the organ of vital emotion, may be said to originate between the eyes—the organs of intellectual emotion, and the tongue—the organ of vital passion, is internally connected with the ears—

the organs of intellectual passion,—yet do they, as it were, not only leave these connexions, but, in the lower animals, gradually approximating, accompany each other even to the end of their snout or muzzle, where the distance between them is almost lost.

PARTS II. AND III.

INTELLECT AND VOLITION.

In conformity with the preceding plan of the work, these subjects should constitute two distinct Parts. Their connection, however, with each other, appears to be closer than their connexion with sensation, and they are also associated in such various ways, that we seem best to follow the plan of nature, by endeavouring to trace these ways in more connected chapters.

Of the parts of the nervous system on which these functions depend, we find the elements even in the class of Zoophytes; as in the œsophageal ring of the holothuriæ and sipunculi. In the other two invertebral classes, the Mollusca and Articulata, this circle is still the most uniform and most essential portion of the nervous system. In the ganglia which are found upon it in some of the mollusca in particular, there appear to me to be interesting analogies with parts of the nervous system of higher animals. In the genus aplysia of the order gas-

teropoda, it would appear that one ganglion corresponds to the trifacial, another to the brain, a third and fourth to the cerebel or rather perhaps to the organs of involuntary motion, and a fifth to the sympathetic. In the articulata, some of these parts are repeated and form a chain of ganglia.*

* " Le ganglion inférieur ou suboral donne quatre nerfs de chaque côté, un pour l'œsophage et les glandes salivaires, et trois pour les muscles de la bouche.

" Le cerveau en fournit trois de chaque côté pour les parties musculaires de la tête, dont ceux du côté droit donnent des filets à la verge, et un pour le grand tentacule, qui donne une branche à l'œil.

" Chacun des ganglions latéraux en donne douze ou treize, qui se perdent tous dans les parties musculaires de la grande enveloppe du corps : je les ai représentés avec exactitude. Le petit collier, qui passe sous l'artère, en donne un impair.

" Les viscères reçoivent les leurs d'un ganglion à part, qui fait par consequent l'office de sympathique ; c'est le quatrième, ou le petit. Il donne un nerf au foie et aux intestins, un autre aux parties de la génération ; celui-ci forme encore un ganglion presque imperceptible, mais rouge comme les autres ; un troisième aux branchies ; le quatrième se perd dans les parties musculaires situées sous le couvercle."—Cuvier, Mem. des Mollusques.

CHAPTER I.

PRELIMINARY VIEW OF THE NERVES, SPINAL CORD, BRAIN, CEREBEL, &c.*

SECTION I.

SUBSTANCES COMPOSING THESE ORGANS.

THESE organs generally are composed of two principal substances, the white and the brown, of which the limits are therefore distinct.

The white substance is that which possesses the most definite fibrous structure, and the brown substance is rather enclosed between the fibres or fibrous bundles of the former, or forms globular portions upon it, or is spread as a layer over its surface.

* The parts described in this chapter pretend to no originality or other merit than those perhaps of brevity and clearness—unless where aught is expressly mentioned as in the author's opinion new, as in pages 235, 6, 7. The whole is a description of mere superficial parts, a reference to which is necessary in the minuter anatomy of the subsequent chapters.

Tiedemann says that, in the fœtus, the white is formed before the brown substance. Serres says that the reverse is the case as to the spinal cord; but Magendie and Desmoulins inform us that, in the fœtus of three months, the walls of the spinal cord are formed only of white fibres; and in the seventh or eighth month, the brown matter is deposited around the central canal; and thus the accuracy of the general fact as stated by Tiedemann is vindicated.

The white substance is more opaque and firm than the brown. Very distinct fibres also are seen in it, particularly if it have been hardened by immersion in spirit, &c.

Prochaska, the Wenzels and Bauer have shown that the substance of the brain is composed of small globules, apparently of cellular texture, and disposed in lines, so as to form fibres. These globules are about eight times less than the red particles of the blood. They are, however, both larger and in greater proportion in the white than in the brown substance. Mr. Bauer has shown that they are connected together by a peculiar gelatinous matter.

In the white substance, few vessels are observed, and injections do not penetrate it deeply.

This substance constitutes by far the greater part of the interior of the brain.

The brown substance is much softer than the white, is less obviously fibrous, and is semi-

transparent. Injections, however, by penetrating its substance to a considerable extent, shew that it is partially composed of blood-vessels.

It has been supposed that the brown matter secretes the white. The increase, however, of white matter never bears the slightest regularity of proportion to the quantities of brown matter; and, therefore, if it do perform that office, it is at certain points only, whence it must intermediately supply fibres and fibrous bundles very remote—a supposition which has occurred to me as obviating objection to its secreting power.

The brown substance may also serve the purpose of supporting and separating the portions of the white, so as to prevent the actions of one portion from affecting, in any way, those of another. Toward the surface, it may be supposed to separate and support the convolutions of the white substance.

SECTION II.

FORM AND STRUCTURE OF THE NERVES.

Soemmerring has stated that the nerves are cones having their apices toward the brain or spinal cord, and their bases toward the skin, the organs of sense, the muscles, or the vessels.

The fibrous structure of the nerves is more obvious than that of the white substance of the brain.

Monro and Fontana have described the nerves as connected by cellular substance, and, like fleshy or muscular fibres, divisible into portions more and more minute.

According to Fontana, the ultimate nervous fibre is about twelve times greater than the muscular fibre, and may be distinguished from it not only by its size, but by being composed of a cylindrical canal of a waved or tortuous form, and containing a viscid pulpy matter.

Reil also describes the nerves as composed of very fine fibres, which seem to differ in thickness, from that of a hair to the finest fibre of silk; each being enclosed in a delicate sheath, called neurilema, and all in their course dividing, subdividing, and uniting again, in the most varied manner, so as to produce everywhere a perfect connexion among themselves.

A greater or smaller number of these fibres forms a bundle or fasciculus, which is also enclosed in its sheath or neurilema; and these bundles or fasciculi divide and unite in the same way as the primitive fibres.

A nerve may consist of one or more fibres, or of one or more bundles.

The various fibres, as well as the bundles in

each nerve, are tied together by the substance which forms their sheaths and the general sheath or covering of the whole.

Thus, although the nerves are not tubes, yet the neurilema is tubular; for the tubes of the neurilema remain when the white filaments of the nerves are dissolved by alkaline lixivia; and when, on the contrary, the neurilema is dissolved by acids, the white filaments of the nerves are seen.

Nerves pass to or from the brain or spinal cord nearly in a right line; separating or uniting under an angle more or less acute, and consequently equally favourable to the motion of their globules from the circumference to the centre, and from the centre to the circumference.

That as nervous fibres of the same kind have communications, nerves of different kinds also possess them, seems evident from the irritation of either muscles or nerves when separated, producing contraction, which could not be effected unless the two kinds of nerves were thus connected at various points throughout their course, and the influence of a single impulse were thus permitted to extend in various directions.

More distant communications are also formed between nerves, by cords which extend from one to another.

In tracing nerves from the brain and spinal cord, the principal branches do not always con-

tinue to subdivide; but, whether belonging to the same or to different nerves, they frequently unite and separate again in various manners to form what is called a plexus, from which new nervous branches arise.

These plexuses not only permit nerves of different kinds to blend, but give protection to nerves in passing joints, &c.

The nerves are generally joined by pairs to the spinal cord or the brain. It will in the sequel be shown, that the anterior nerve in each pair is an ascending, and the posterior a descending one.

It is remarkable with regard to the nerves, as it is with regard to other parts forming pairs in the nervous system, that the anterior or ascending fibres, bundles, or masses are always smaller, and the posterior or descending fibres, bundles, or masses are always larger.

In the spinal chord of man, the two bundles of fibres forming each nerve do not unite until after the posterior or descending bundle has formed a swelling or ganglion.

The union is formed by about half the fibres of each root crossing between the fibres of the other toward the opposite branch, while the other half of each root runs onward in the branch of the same side; a rather greater number of fibrils, however, passing from the posterior root to the anterior branch than from the anterior

root to the posterior branch. This obvious and important anatomical fact was, I believe, first described in my Paper in Thomson's Annals of Philosophy for August, 1815.

These nerves then separate into two branches, both of which communicate with the great sympathetic, ganglionic, or vital, nerve of the trunk, by one, two or more filaments; and a ganglion is always formed at the place where they unite with that nerve.

The division of nerves into those of motion and those of sensation is perhaps not sufficiently expressive, because all nerves are nerves of motion. The more correct division is into nerves of sensation, and nerves of voluntary or involuntary motion (for both of which latter terms Sir A. Carlisle substitutes "nerves of direction"), or nerves of impression, and nerves of expression.

As sensation cannot reach the brain without an ascending motion—a motion towards the brain; as the consequent volition cannot affect the muscles without a descending motion—a motion from the brain; and as it is contrary to all analogy that there should be motion in opposite directions in the same tubes of neurilema, —for these reasons, there must be a series of nerves appropriated to each.

Now as, in some cases, sensation exists without volition,—as nerves of mere sensation without volition are generally of softer structure, as

the olfactory, auditory, optic, &c.—as nerves at once connected with sensation and volition consist of firmer fibres, as the generality of nerves do,—and as almost all nerves arise by distinct filaments, — it is evident that wherever a part having both sensation and motion, is supplied from one nervous trunk, that trunk envelopes both a nerve of sensation and one of voluntary or involuntary motion.

In short, anatomy shows us that though nerves supplying parts which are contiguous in position but different in nature often run in one common sheath, yet on arriving at the spinal chord they split into two roots, as they are termed; that these roots are quite different in form, the anterior being more fibrous, and the posterior more simple and round; that the anterior roots join the anterior columns of the spinal chord, and the posterior roots the posterior columns; that these columns actually do join the cerebrum or greater brain and cerebel or less brain respectively, &c.

The functional difference between the nerves of sensation and those of volition, is merely that their motions take place in different directions. The latter, therefore, may be said to resemble the arteries; the former, the veins.

SECTION III.

FORM AND STRUCTURE OF THE SPINAL CORD.

In quadrupeds, the spinal cord, or prolongation of the brain, which occupies the canal formed by the bones of the spine, or vertebræ of the back, becomes more completely subordinate to the brain than in the inferior classes of animals.

In man, the nervous system is characterized by still greater centricity; and the spinal cord becomes still more completely an appendage of the brain, by diminution of size, by recession from the lower part of the spinal column, by absence of the canal found within it in quadrupeds, and by the disappearance of distinct gangliform enlargements.

I may here premise a few words respecting the general structure of this organ.

The spinal cord, which may be said to be thick, long, and irregularly cylindrical, extends from the brain, within the spinal or vertebral canal, nearly as low as the first or second lumbar vertebra.

Its thickness varies at different parts; being greatest at its cranial part, the oblong process of the brain, technically called medulla oblongata,—thence gradually contracting as it passes out of the cranium,—again enlarging toward the

middle of the cervical region,—a second time contracting,—again becoming thick in the lower part of the dorsal region, and—then gradually tapering to a point.

The spinal cord has a fixed position in the middle of the vertebral canal, a little nearer its anterior than its posterior side.

The upper or cranial portion of the spinal chord—the oblong process of the brain or medulla oblongata, extends from the transverse ring or annular tubercle to the great occipital hole of the skull, contracting as it descends, and being compressed before and behind.

The anterior convex surface of the oblong process, which lies upon the occipital bone, has upon it four eminences placed longitudinally and side by side.—Two of these called pyramidal eminences, corpora pyramidalia, are internal, and are separated by a median groove, deeper above than below, and continued down the anterior surface of the spinal cord to its extremity. The eminences themselves are more prominent, if not broader, superiorly; but, after extending about half an inch downward, they gradually disappear in the anterior columns of the spinal cord.—The two lateral eminences, separated from the preceding by a slight depression, are named the olivary eminences; and may be subdivided into the olivary bundles and the olivary bodies. They are firm, oblong, pro-

minent in the middle, rounded at the extremities, and white externally.

The posterior surface of the oblong process is not crossed by, but becomes laterally continuous with, the transverse ring, no line of separation being interposed. In the middle, it contributes to form the fourth of the great cavities or ventricles of the brain, and in the median line, it is hollowed by a part of the groove, called the pen or calamus scriptorius. On each side, are the two whitish oblong eminences called the inferior peduncles of the cerebel, or corpora restiformia, which descend from that organ. Between those, and consequently in the bottom of the fourth ventricle, are two slender cords partly in apposition at the median plane, sometimes called the posterior pyramids.

Of the rest of the spinal cord, the anterior surface, besides a number of small transverse furrows about its middle part, presents a deep longitudinal fissure running along it from one extremity to the other, and dividing it into two equal lateral portions.—Its posterior surface, besides presenting slighter transverse folds, is also divided throughout its length by a longitudinal fissure, of which the sides are closer and less deep than those of the anterior, and which commences between the inferior peduncles of the cerebel. — By these grooves, the spinal cord is deeply divided into two great lateral portions.

There are, however, subordinate divisions of these lateral portions; for, on examining the anterior and posterior surfaces of the spinal cord, we find, on each side, and at some distance from the middle groove, a collateral one, which is rather superficial and broad, and to which are attached roots of the spinal nerves. —The two anterior collateral grooves commence between the pyramidal and olivary eminences, and are closer, more superficial, and at their bottom whiter and firmer, than the posterior ones.—The posterior commence between the olivary eminence and the posterior peduncles of the cerebel, are at first slight, but become broader and deeper as they descend, each dividing into two parallel lines, which gradually disappear inferiorly. These grooves are more marked than the anterior ones, have rounded and white edges, and a reddish and soft bottom.

The two furrows, moreover, which, in the oblong process, intervene between the inferior peduncles of the cerebel and the smaller cords behind them, are continued down two thirds of the spinal cord between the posterior median and posterior lateral furrows.

Nor are even these the whole; for though, in the middle of each lateral surface of the spinal cord, there is frequently no longitudinal groove, yet I have myself sometimes seen it, and Soem-

merring, Portal and many other anatomists have described it, proving at least the tendency to such division.

Thus there are found ten deep or superficial grooves upon the spinal cord, marking the limits of as many columns; and, besides these, there appear to be three or four deeper seated columns, of which the superior part is described by Reil, making thirteen or fourteen, in all.

That these columns, in the oblong process and spinal cord, are continuous, is illustrated even by the rough and hasty operation described by Mr. Mayo. — "The connexion, he says, of the parts of the spinal chord with those of the medulla oblongata has appeared to me the following. If the posterior pyramid be detached from the margin of the lozenge-shaped field of the fourth ventricle, it appears prolonged as a fasciculus on either side of the posterior median furrow. If the corpus restiforme be detached from the cerebellum, and drawn downwards, it carries with it a broad lateral surface of the spinal chord, including in its centre the posterior lateral furrow [that is, it takes with it the posterior or descending half of the lateral portion of the chord, limited anteriorly by the slight middle lateral furrow described by Soemmerring, Portal, and others]. If all the superficial substances between the internal margin

of the corpus restiforme and the anterior pyramid, that is to say, the corpus olivare, with its lateral adherent fasciculi, be drawn downward, the remaining surface of the spinal chord is raised, which contains the anterior lateral furrow [that is to say, it takes with it the anterior or ascending half of the lateral portion of the chord, limited posteriorly by the slight middle lateral furrow]. Finally, if the anterior pyramid be divided at the inferior margin of the annular protuberance, and drawn downwards, it is seen, at an inch from the latter substance, to dip obliquely backwards, to cross over to the opposite side, decussating the fasciculi of its fellow, and then apparently to descend in the length of the spinal chord within the prolongation of the corpus restiforme, accompanied, it would seem, by an extension of substance from the floor of the fourth ventricle."

Like the nerves, the spinal cord indeed consists chiefly of longitudinal threads, some of which Mr. Mayo has observed to extend from the oblong process to the end of the cord, and between which, numerous oblique communications take place, while white fibrils at intervals detach themselves to form the spinal nerves.

In the bottom of each median furrow, anterior and posterior, is seen a layer of white substance. In the posterior, this appears to be formed by two longitudinal bundles. In the anterior, it is

evidently formed, superficially at least, by transverse filaments. Hence, when the two anterior columns of the spinal marrow are separated, innumerable commissures appear, which are no doubt those of the spinal nerves.

In the oblong process, and especially in its median plane, may also be observed many upright or radiating fibres, which seem to be one cause of the remarkable swell of this portion of the brain. So numerous are these, that, in some sections, the oblong process seems to be almost a case of white matter enveloping fibres ascending toward the bottom of the fourth ventricle.

As to the general function of the spinal cord, it is here only necessary to observe, that, if a division of it be made, the parts supplied with nerves given off below it, are paralized, or placed out of controul by the will.

I think it probable, however, that, in the spinal cord, as in the ganglia, the brown matter is interposed between the unions of nerves wherever they are of different kind, and especially where a return of action is made; and thence irritation of surface excites involuntary muscular action. It perhaps, also by interposition, prevents the actions of the anterior from affecting those of the posterior columns, and vice versa.

SECTION IV.

EXTERNAL FORMS AND GENERAL STRUCTURE OF THE BRAIN.*

The brain has three investing membranes; the outer, technically called dura mater; the middle, called tunica arachnoidea; and the inner, called pia mater.

The greater brain or cerebrum is the principal substance contained in the cavity of the skull; of which it occupies the upper part, extending from the forehead to the upper back part of the head, and resting before upon the roofs of the orbits, in the middle upon the deep middle cavities of the skull, and behind upon a transverse broad and strong semicircular fold of the outer cerebral membrane, technically called tentorium cerebelli.

The outline of the brain viewed from above is an ovoid, generally broader behind; it is convex above, and in general most so posteriorly; it is somewhat compressed laterally, and it is flattened inferiorly.

Even in viewing the exterior of the brain, I shall endeavour to describe its parts, wherever that seems possible, in the order of the functions

* The surfaces seen in the ventricles are here included.

which they exercise; and I shall therefore begin with its lower surface or basis.

Nearly in the centre of this surface, we observe two broad, longitudinally fibrous and fasciculate, white cords, called the peduncles of the brain, technically crura cerebri, which posteriorly are close to each other, but as they proceed forward and outward, recede from each other, and increase in size. They are apparently connected together by a white plate forming the floor of the third ventricle.

Still diverging forward and outward, they pass anteriorly and laterally over two white cords, much more slender, the optic nerves, here diverging outward and backward, and bending around the peduncles, to which they are connected anteriorly by soft substance. From the line thus formed, the fibres of the peduncles separate and expand through the cerebral lobes.

The cerebral lobes are three on each side; an anterior, resting upon the roofs of the orbits; a middle, descending into the middle lateral cavity of the skull; and a posterior supported by the transverse fold of the outer cerebral membrane, or tentorium. When the brain is viewed from below, this last lobe on each side is nearly hid by the cerebel.

On the base of the brain, of which the greater parts are thus enumerated, we may first

notice, at the forepart, and in the median line, a fissure which is the commencement of the great fissure separating the hemispheres, and therefore receiving in its forepart the longitudinal broad and strong semicircular fold of the outer cerebral membrane, technically called falx cerebri. On separating the sides of this fissure, is seen, above, the anterior part of the great superior commissure uniting the two hemispheres of the brain, technically called the corpus callosum, and the sides themselves are the flat and inner sides of the two anterior lobes.

Nearly at a right angle to the preceding fissure, and on each side of the base of the brain, is another fissure or depression called that of Silvius, which separates the anterior and middle lobes, and receives one of the chief branches of the internal carotid artery. This fissure is continued upward and backward upon the surface of the hemisphere, and corresponds to the bony ridge separating the anterior and middle cavities of the internal base of the skull.

Of this transverse fissure, the inner end turns inward and backward, into a shorter longitudinal fissure, which runs between the cerebral peduncles and optic nerves internally, and the middle lobes externally, and which allows the inner membrane of the brain to pass into the lateral ventricles, but is closed by the middle

membrane. Posteriorly it communicates with a transverse fissure which, in this inferior view, is hid by the cerebel, before which is seen the oblong process of the brain.

Between the middle and posterior lobes of the brain on each side, is a fissure, or rather superficial depression, which runs obliquely backward, and corresponds to a bony ridge separating the middle and posterior cavities of the internal base of the skull.

A fissure divides also the posterior lobes in the median line, being the termination of the great fissure between the hemispheres, and lodging the end of the longitudinal fold of the outer cerebral membrane, or falx cerebri.

The remaining fissure has been already alluded to, as, in the inferior view, concealed by the oblong process of the brain, between which and the posterior extremity of the great commissure, uniting the two cerebral hemispheres, it is found. This fissure, which is transverse, permits to pass, into the third ventricle, the middle and inner membranes of the brain, and contains what has been called the arachnoid canal and the pineal gland.

Having thus seen the general configuration of these parts in the base of the brain, the minuter objects which they present may be examined.

The most obvious circumstance on the whole surface is that it is composed of convolutions,

which are themselves less sinuous and have divisions less deep, than those of the upper surface of the hemispheres.

On each anterior lobe is a deep groove, which passes from before backward and receives the olfactory nerve.

Near to the commencement of the fissure separating the anterior and middle lobes, is a whitish space which presents several apertures permitting the passage of vessels, and which is technically called lamina cribrosa. It presents also striæ, and is continued to the great commissure.

Between these two fissures, is also the commissure of the optic nerves. It is important here to observe, that from the upper surface of this commissure ascends a grayish membrane, pulpy, but firm, somewhat transparent, but little vascular, which closes the anterior extremity of the third ventricle, proceeds to the anterior and inferior part of the great commissure, and joins the thin partition or septum lucidum of the lateral ventricles.

Behind the commissure of the optic nerves, and connected with them, is a greyish tubercle, which extends backward to and somewhat around the pisiform or mammillary bodies. It contains some white substance in its centre, and forms part of the floor of the third ventricle.

From the middle of this tubercle descends

somewhat forward the pituitary stem, a slender conical process, of reddish colour, terminating in the pituitary gland.

This is a roundish body which is contained in its peculiar cavity in the centre of the base of the skull, being enveloped by the outer membrane of the brain, except at its upper part, over which passes the middle membrane.—Its structure does not resemble that of glands : it is composed of two portions, of which the anterior is larger, and the posterior smaller and softer. Its colour is a greyish yellow. Like the pineal gland, it sometimes contains small concretions.

The pisiform or mammillary bodies, which are situated behind the grey tubercle, are about the size of a pea, white externally, grey within, and united by a greyish band which forms part of the floor of the third ventricle.

Behind these and between the peduncles of the brain, is a triangular space, the white substance of the bottom of which also, as already said, forms part of the floor of the third ventricle.

The lateral surface of the brain is, in its outline, rather more than half an ovoid ; its convexity being above, and its flat or rather irregular surface below. The fissure dividing the anterior and middle lobes is seen running upward and backward upon it. Its convolutions are more sinuous, and their divisions deeper, than those of the basis.

The upper surface of the brain presents, in the median line, the deep fissure, which receives the longitudinal fold of the outer membrane, or falx cerebri, and which divides it vertically into two hemispheres, a right and left. From the description of the base of the brain, it has already been seen, that both before and behind, this fissure divides it in its whole height; but, in the middle of the superior part, the brain is united by the great commissure, as it is below by the parts already described.

The hemispheres of the brain, viewed superiorly, have each the outline of half an ovoid, but, as we have now seen that they are flattened below, as well as on the inner side, their whole form is the fourth of an ovoid. At the bottom of the median fissure, they appear to be continuous in the middle with the great commissure.

The convolutions on the upper surface of the hemispheres are more sinuous and their divisions deeper, than elsewhere, extending sometimes to an inch from the surface. Their number, size, and direction, vary considerably. Some of them are simple, but many in their course present subdivisions, and are continuous with others. In the divisions, moreover, are sometimes concealed secondary convolutions, which occupy corresponding depressions on contiguous ones.

Passing now to those surfaces of the brain which are seen in the ventricles, I shall endea-

vour to describe them also as much as possible in physiological order.

The anterior striated bodies technically called corpora striata, of which there is one in each lateral cavity or ventricle, are the first of the internal surfaces I shall notice, because the fibrous bundles within them are the continuation of the peduncles of the brain, which were first described externally.

These bodies form the fore part of the floor of the lateral ventricles. They are pyriform, broad before, narrow behind, of brownish grey colour, and so placed that, while near each other anteriorly, they are separated to a considerable distance posteriorly. They are contiguous to the great commissure above, and the thin partition of the ventricles within.

The posterior striated bodies, technically called thalami nervorum opticorum, or optic thalami, are seen in the lateral ventricles, in the third, and at the exterior of the brain. Their figure is rounded, irregular, and larger behind than before, and they are invested with white substance.

The upper surface of each, which forms part of the floor of the lateral ventricle, has a slight depression in its longitudinal direction, and a small tubercle at each of its extremities. Its outer surface is joined to the anterior striated body. Its inner surface, which is flat,

constitutes the sides of the third ventricle, and is connected anteriorly with the opposite side by a transverse grey band. Its inferior surface presents externally two prominences, called the geniculate bodies, internal and external, which seem to receive filaments from the olfactory and optic nerves respectively. Its anterior extremity contributes to the aperture from the lateral to the third ventricle. Its posterior extremity is free, and corresponds to the curve of the lateral ventricle.

As these bodies form the floor, so the great commissure, technically called corpus callosum, forms the roof of the same part of the lateral ventricles. This is a long and broad, but not very thick, band of fibrous white substance. Its situation is nearer the anterior than the posterior part of the brain. Its direction is horizontal. Its breadth is greater behind than before. Its shape is quadrilateral, but curved upon itself, being convex from before backward, but straight in the transverse direction.

The upper surface of the great commissure is concealed by the hemispheres; but, when these are separated, there may be observed, along its middle, a prominent longitudinal line of a compact texture, which penetrates the substance of the commissure, and which is technically called the raphe. Externally to this, is a surface of some extent, which presents many

transverse prominent lines, called transverse traces, which are most distinct posteriorly, and which terminate at the raphe.

The lower surface of the great commissure, being free from attachment to a great extent, forms the roof of both the lateral ventricles, by stretching across them from side to side. In the middle, it also covers the arch, vault, or fornix, which runs in the opposite or longitudinal direction through the middle of the floor of these cavities, and over the inner and posterior part of the posterior striated bodies; the commissure being, by its posterior edge, continuous with that arch behind; and the thin partition, or septum of the ventricles, being extended between their separated anterior and middle part.

The anterior extremity of the commissure bends downward and backward, forming externally a rounded prominence between the hemispheres, extending as far as the base of the brain, towards the fissure between the anterior and middle lobes and the terminations of olfactory nerves, and terminating by whitish matter, which disappears about the peduncles of the brain; thus surrounding the fore part of the anterior striated bodies, and forming the anterior part of the floor of the lateral ventricles.

The posterior extremity of the great commissure bends, on the contrary, downward, forward, and outward, forming a white plate,

which spreads into the lower part of the lateral ventricles, and which on each side invests brown substance, and forms what is technically called the hypocampus or bend, turning so as to form its concavity inward and forward, and its convexity outward, and terminating by a bulbous extremity, turned inward, and surmounted by two or three slight tubercles, separated by shallow grooves. Throughout this course, the upper surface of the bend or hypocampus is free in the bottom of the ventricle, though a vascular cord, called the choroid plexus, lies over it. Its posterior convex edge is limited by a groove, behind which, in the bottom of the ventricle, is a swelling called the additament, which follows the direction of the greater bend, and is sometimes as large. Its anterior concave edge is covered by what is called the fimbriated body, under which is a denticulated cord, of compact texture, granulated appearance, and reddish colour.

The thin partition, or septum of the ventricles, is a flat and white fibrous expansion, continuous above with the median line of the inferior surface of the superior commissure, before and below with the recurved anterior extremity of the same body, and below and behind with the convex surface of the arch or vault. Being high at its fore part, and diminishing backward, its form is somewhat triangular. So far

as it extends, it separates the lateral ventricles from each other.

This partition, which is covered by the middle membrane, is composed of two layers, between which exists a separation which is less apparent in the adult than in the fœtus, and which is sometimes filled by serous liquid. At its inferior part, or under the anterior commissure, has been observed a small depression, a bristle passed into which, it is said, penetrates into the third ventricle; but in the natural state, the aperture cannot be observed.

Beneath the superior commissure and the thin partition, lies the arch, vault or fornix. This is composed of white, fibrous substance, and somewhat resembles a long triangle, of which the middle part is placed horizontally, but of which the extended apex, which is directed forward, and the posterior sides or pillars, which are directed backward and outward, are also bent downward. It forms part of the two lateral ventricles above, and of the third ventricle below.

The anterior extremities or pillars of the arch consist of two cylindrical bundles which, being at first contiguous, bend round the anterior striated bodies, and turn downward behind the anterior commissure; then, separating a little, penetrate the substance of the convolutions, reach the pisiform tubercles in the basis of the brain,

and again turn upward, in a course which, as altogether internal, need not at present be described.—It is behind each of these cords, that exists the small oval aperture, by which the lateral ventricles communicate with the middle ventricle, and by which the choroid plexus passes.

The upper surface of the arch is, as already said, contiguous to the superior commissure, and, in the median line, continuous with the partition of the ventricles.

The inferior surface of the arch rests upon the posterior part of the posterior striated bodies, and the interposed choroid web, which is composed of minute arteries and veins. Posteriorly, it is said to present a few striæ or prominent lines, called the lyre; but these rather belong to the great commissure.

The posterior pillars of the arch have each an internal short branch, which loses itself in the bend, and an external long one called the fimbriated body, corpus fimbriatum. The last is a flattened band, which has been already described as passing along the concave edge of the bend, into the bottom of the lateral ventricles, and which at length loses itself near to where the inferior aperture of the ventricles is shut by the middle membrane.

On the outer side of each lateral ventricle is a white band which runs from before backward.

In the bottom of each, and crossing it from

before backward and outward, in a groove between the anterior and the posterior striated bodies, is a fibrous, thin and semitransparent semicircular chord, tœnia semicircularis, which beginning, by one or more filaments, before the anterior extremity of the posterior striated body, is covered by a delicate transparent plate of a yellowish colour, called the horny lamina, beneath which is sometimes a little serous liquid, and passes backward and downward, gradually contracting, and at last disappearing towards the external geniculate body.

The lateral ventricles are two cavities symmetrically disposed, one in the right, and another in the left hemisphere of the brain. They may be considered as beginning at about two inches from the extremity of the hemispheres, behind the fissure between the anterior and middle lobes, where they are nearly an inch apart. They next pass upward, backward, and inward, and are separated only by the thin partition. They then gradually separate again, running directly backward as far as the posterior part of the great commissure.

At this part of their course, takes place from each ventricle a triangular prolongation into the substance of the posterior lobe, called the digital cavity, or posterior horn, which has its base before, and is so curved as to have its concavity inwards.

The ventricles then continue downwards, outwards, and forwards, approaching each other inferiorly, and ending under the point at which they began.

The upper portion of the lateral ventricles is rather broader before than behind, and is prolonged into the anterior lobe by a small angular cavity, called the anterior horn. It is formed above by the superior commissure; below, by the anterior fold of the same body, the anterior striated body, semicircular cord, the posterior striated body, and the arch; within, by the thin partition; and without, by the lateral band already described.

In the digital cavity, is only to be noticed, on its floor, an eminence, broad before, pointed behind, and bent inwards, called the spur or unguis, which is also broad before, pointed behind, and bent inwards, agreeably to the form of the cavity.

The lower portion of the lateral ventricle, is long, narrow and bent, having its convexity externally, and occupying a part of the posterior and the whole of the middle lobe. Its sides are formed by the fimbriated body, the bend, its additament, and a small greyish band.

The lateral ventricles are throughout divided by a slit formed between the posterior striated bodies and the edges of the arch, and of this slit the direction is followed by the choroid

plexus. It begins on each side at the communication with the third ventricle, and ends at the base of the brain, where it is closed by the middle membrane.

Between the posterior striated bodies, is the third ventricle, placed in the median line, single, and much less than the lateral. Its greatest length is from before backwards, and its greatest depth from above downward.

As already said, the sides of the third ventricle are formed by the posterior striated bodies, which are mostly contiguous, and united only at one point, as formerly mentioned.

Its upper side is smaller than its lower, and is formed by the arch and the interposed choroid web.

Its upper forepart is formed by the anterior commissure; and its under forepart is closed by the nervous membrane which rises from the commissure of the optic nerves.

Its bottom, which is very thin, forms part of the surface of the brain. Behind, it is formed by the plate between the two peduncles of the brain; and before, by the grey tubercle behind the optic commissure. As the ventricle becomes narrow and deep, especially toward the pituitary stem, it is there called, the infundibulum.

At its back part, the third ventricle is limited by the posterior commissure, beneath which is the small posterior aperture of the ventricle, or

beginning of the passage from the third to the fourth ventricle, which runs backward beneath the four tubercles.

As to general structure, the brain may be said to consist of a white centre or nucleus, within which are the ventricles, and without which are the convolutions, and of gray substance, which is within, as well as on the surface.

The centre is composed of the parts continuous with the peduncles and several bundles of the spinal cord, or the vertical portion, of those continuous with the great commissure, or the horizontal portion, of the arch, &c.

The arrangement of the cerebral fibres is various. Those ot the peduncles and great commissure are disposed in parallel flattened bundles; those of the convolutions, in medullary plates; those of the arch and the anterior commissure, reticularly; those of the fibrous cone, the tapetum, &c. in radii.

Every cerebral bundle has a distinct but delicate sheath, called epithelium, which consists of a fine transparent production of the inner membrane of the brain, and a layer of nervous matter within this, either white or grey. This, as observed by Reil, admits of very distinct demonstration on the partition of the ventricles, and on the anterior striated body; and the Wenzels add, in the cavity between the layers

of the partition, in the posterior horns of the lateral ventricles, and on the floor of the fifth ventricle. Reil observes that, where the great commissure joins the outer margin of the anterior striated body, the epithelium appears to split into two layers; one of which invests the inner surface of the anterior striated body, and the other passes between its grey matter and the fibrous cone, each bundle of which it seems to clothe down to the margin of the posterior striated body; and so general is the obvious distribution of the membrane, that he thinks it probable that each plate, even in the convolutions, has a tunic derived from it.

SECTION V.

EXTERNAL FORMS AND GENERAL STRUCTURE OF THE CEREBEL.*

In superficially describing this organ, I shall follow the division of Reil.

The cerebel lies below the posterior lobes of the brain and the interposed transverse fold of the outer membrane, in the posterior or deepest cavity of the base of the skull.

The cerebel is less than a third of the size of the brain, measuring transversely, at its greatest breadth, from three inches and ten

* The surfaces even in the fourth ventricle, are here included.

lines, to four inches; longitudinally, above, and in the centre, twenty lines; and either lateral portion being two inches long, and about sixteen lines thick at its middle.

Its form, which is symmetrical, corresponds to that of the cavity containing it. Its height is less than its breadth, so that it may be compared to two depressed spheroids, placed beside each other, and joined by a portion of their surface. It is of a reddish grey colour externally, and is more subdivided, and, therefore perhaps, proportionally lighter, than the brain.

The upper surface of the cerebel, though flattish, is not horizontal, but raised a little anteriorly towards the four tubercles, and depressed laterally and behind.

The central part is called the general commissure, and consists of two portions, the superior and inferior vermiform processes, of which the superior terminates at the commissure of the upper and posterior lobes.

The vermiform processes are composed of corresponding portions on either side of the median plane; there is no material difference in the structure of the upper and under portions; and thus the whole is one homogeneous organ.

The lateral parts are called hemispheres. When viewed from above, these are externally circular; but internally, where they approach

to join the general commissure, their margin is deeply notched both before and behind. Thus the fissures are formed, one called the semi-lunar fissure, towards the cerebrum, and receiving the four tubercles; the other, termed the purse-like fissure, backwards, and receiving an inferior longitudinal fold of the outer membrane, technically called falx cerebelli.

The under surface of the cerebel is somewhat hemispherical, having, however, along its middle a deep and broad depression, the valley, extending from before backward, in which is lodged the oblong process or medulla oblongata, as well as the inferior vermiform process.

In the valley, the inferior vermiform process is separated from the hemispheres on either side by a furrow. The valley is broadest at its middle, where the pyramid is placed: behind this point, it is contracted by some of the lobes to be now described.

Each hemisphere has five lobes, of which two compose the upper, and three the under surface.

The square, or anterior and upper, lobe is on either side of the superior vermiform process, and unites its transverse plates, forms the fore part of the upper surface of the cerebel, and extends from the four tubercles backward to what is called the single commissure of the upper and posterior lobes.

The posterior and upper lobe forms the upper and posterior surface of the cerebel, extending as far as its margin: its limits are easily defined by tracing its union with its fellow, by means of the single commissure, and thence following the furrow, which is continued outward to the horizontal fissure betwixt this lobe and the next.

The lower and posterior lobe is united to its fellow by the short and exposed commissure, and by the long and hidden one; and it sometimes adheres to the posterior surface of the pyramid.

The slender lobe is joined to its fellow, sometimes by the last plate of the long and hidden commissure, but, for the most part, by the plate of the posterior part of the pyramid.

The biventral lobe lies between the slender lobe and the almond-like lobe, and is the last which conforms to the circular arrangement of the parts upon the under surface of the cerebel.

The almond-like lobe is pressed inwards towards the valley.

The horizontal or lateral fissures are those depressions, which extend transversely across the fore part of the cerebel, and contain the processes passing to the transverse ring or annular protuberance. These fissures are continuous with the intervals between the upper and under posterior lobes, which extend as far as

the purse-like fissure: thus a deep furrow may be traced round each hemisphere, dividing the cerebel into an upper and an under portion.

Inferiorly, the cerebel has six processes of white matter, three namely on either side. Of these, the anterior pair, lying innermost, extend between the cerebrum or greater brain, and its back part; the posterior pair, lying external to these, extend between its fore part and the spinal cord in the canal of the back; and the lateral pair lying outermost, extend between its sides and the oblong process, medulla oblongata, at the bottom of the brain. The first pair are called the anterior peduncles of the cerebel; the second, the posterior; and the third, the lateral.

At the junction of these three peduncles in the cerebel, they form a mass, in the middle of which is an elongated ovoidal nucleus or centre called the serrated body, corpus serratum, or dentatum, which is circumscribed on all sides by a very distinct undulated line of a yellowish colour.

Above and around, the central matter appears to divide successively into medullary centres or nuclei, stems, lobes, lobules and laminæ, which last are invested with cortical matter. To sections of this assemblage, the foolish name of arbor vitæ has been given.

The surface of the cerebel is that laminated

plated structure, in which the medullary processes rising from the centres terminate. The plates are from a line to a line and a half thick, in apposition with each other, concentric, more extended posteriorly, shorter before, and separated by narrow grooves, which are lined by the inner, and over which the middle membrane passes. No plate is confounded with another, and no one extends round the organ.

As already indicated, the plates are divided by furrows of greater or less depth, which are more or less parallel to each other, and constitute each a segment of a circle, the convexity of which is turned backwards, and the horns forward and toward the horizontal fissure.

On separating the principal plates, others of less dimension are found to be concealed in the fissures and partly covering each other.

The deeper furrows pass down to the medullary centres, and form the boundaries of lobes: the shallower furrows, which are not continued over the entire surface of a hemisphere, form the boundaries of lobules.

Internally, or between the peduncles of the cerebel, is found its ventricle, called the fourth, formed at once by the cerebel and the oblong process.

The anterior side, sometimes called the floor, of this ventricle, is formed by the posterior surface of that process. This presents to us the

lozenge-shaped field of which the margins are made out by the peduncles. This space is narrow above, where it is the continuation of the passage from the third to the fourth ventricle, wider below this, and again contracted inferiorly. It is covered by a layer of greyish substance, and divided longitudinally by a narrow angular groove, called the pen, or calamus scriptorius, which begins above, and ends in the spinal chord opposite the first vertebra or bone of the neck. Several delicate white filaments proceeding downward and inward, slightly applied upon the surface of the ventricle, and constituting one of the terminations of the auditory nerve, meet in this groove.

The lateral parts of the ventricle are limited by the peduncles, but in such a manner that its cavity is broader above than below.

Its posterior side, which is formed by a part of the anterior notch of the cerebel, is shorter than the anterior.

Its upper extremity is closed by the thin expansion called the valve of Vieussens. This is a pulpy plate, very thin, and of greyish colour, which ascends from behind the four tubercles towards the cerebel, is connected on each side to the superior peduncles, passes beneath the anterior notch of the cerebel, and, becoming broader, and a little thinner, is united to the posterior side of the ventricle.

Its lower extremity is closed apparently by the inner membrane of the brain.

A mass of blood-vessels and reddish granulations, is designated by the name of choroid plexus of the fourth ventricle.

The lateral peduncles of the cerebel are narrowest at their commencement, but become broader as they pass forward to form the transverse ring, being each convex and rounded externally.

The anterior surface of the transverse ring which internally embraces various bundles ascending to and descending from the brain, is thick, convex, and rests upon a groove in the base of the skull. It is marked along the median line by a groove which is rather broad and rounded at the bottom, and by smaller transverse grooves, which lodge branches of arteries.

It is limited on the edge which is next to the peduncles of the brain by a circular depression, deeper anteriorly and more superficial posteriorly; and below, by a contraction which separates it from the spinal cord.

SECTION VI.

EXTERNAL FORMS OF THE TUBERCLES, &c.

The oblong portion of the brain on which the four tubercles are placed, is, in the natural si-

tuation of parts, almost entirely concealed by the inferior notch of the cerebel.

The tubercles on its upper part are rounded, white externally, grey internally, arranged in pairs, and separated by two grooves, which pass in a crucial manner between them.

Of these tubercles, the two upper, situated immediately behind the posterior commissure, are larger, broader, and more prominent than the inferior.

Above the tubercles is the pineal gland, a greyish body, of the size of a large pea, varying slightly in form, and of pulpy consistence.

It is isolated from the brain, except at its fore part, where it receives two cords of white substance, the peduncles of the pineal gland, from the upper and inner part of the posterior striated bodies, after these have passed over the sides of the posterior aperture of the third ventricle, and united.

The pineal gland frequently contains, in the adult, a number of small transparent calculi, varying much in their number and disposition.

The arteries of the brain are branches of the internal carotid and vertebral arteries, branches from which, by uniting or anastomozing, form what has been called the arterial circle of Willis. —The spinal cord receives its arteries from the vertebral, dorsal, lumbar, and sacral arteries.— The veins of the brain open into the great canals

or sinuses which are formed by the folds of the outer membrane, and these empty their contents into the internal jugular veins.—The sinuses of the spinal marrow end in the vertebral, dorsal, lumbar, and sacral veins. No lymphatic vessels have yet been seen in the tissue of the brain.

ADVERTISEMENT

TO THE

FOLLOWING MORE IMPORTANT CHAPTERS.

In the present state of anatomy, the first duty of a physiologist is to know what others have done; the second, to verify their facts as far as he has the means; and the third, to add to the stock of facts wherever they are incomplete or insufficient for the purpose of reasoning.

The first and humblest of these duties is especially important in cerebral anatomy.

As the substance of the brain may be explored in an almost infinite number of points and directions, and as each point and each view may present something new, its minute anatomy is equivalent to a search for objects barely visible and scattered over an immense space. It may easily, therefore, be understood how necessary it is to learn carefully all that others have done, before we either think of adding to the number of facts, or of reasoning respecting them.

In the anatomy of the brain, it is indeed perpetually possible to cut within a hair's breadth of an object, or even to cut across it, without distinguishing its lateral or transverse aspect from the substance in which it is imbedded. Yet, at this very point, a slight inclination of the scalpel shall display an extended silvery cord, or a splendid expansion of fibres.

To think, therefore, of unravelling the brain without being perpetually aided by the labours of previous anatomists, is equivalent to saying we shall discover, with our own hands and eyes, all that has required the inspection of thousands during many centuries. The task would be one of the most extravagant and hopeless that ever was undertaken.

It seems evident, however, that one of the first duties of a physiological writer is to give to the philosophical student entire confidence in the facts he assumes. And there seems to be no mode of doing this, but by referring to, or (to save much expense and labour to the student) by briefly quoting, the enunciations of these, by discoverers who have proved themselves almost unerring as to the statement of mere facts.

In this and the following chapters, therefore, I insert such statements, pointing out, at the same time, any error of method which they present. A brief and simple description would

have been far easier than a critical one of this kind; but the authority of discoverers, and especially of Reil, and the warning as to method which his example holds out, are both invaluable on this occasion. I also subjoin, in footnotes, the original passages from the works of Reil, Rolando, Tiedemann, the Wenzels, and others, whenever these, with, or without facts of my own, are the grounds of any important conclusion.

The reader will thus at all times be in the condition of judging for himself; and when, a few years hence, he looks back on what cerebral physiology now is, or rather on what it is not, and contemplates what it has then become, he will probably acknowledge the value of the method now adopted, as well as that it was high time to derive enlarged physiological views from the accumulated facts of anatomy.

As to the facts originally added by myself, their representation is quoted from the works in which they first appeared, chiefly "Archives of Science" for April and July, 1809.

These facts are shown to be consistent with many partial and detached observations of Reil, who published his first Papers on the Cerebrum* in his "Archiv für die Physiologie" for 1809, and

* With his previous Papers on the Cerebellum, the views to which I lay claim have no interference.

his last in the same work for 1812. It is not a little curious that my last publication on the cerebrum, in the work just mentioned, namely in July 1809, and Reil's first, in the work of similar title, must have taken place in the same month, if the date (1st of July) attached to the advertisement in the first part of his first volume, continued to be that at which he published; and as his volumes seem to have appeared in half yearly parts, it is not improbable that they were regularly published in July and December.

Be this as it may, there is no interference or anticipation with regard to either; for Reil's observations are generally partial and detached, frequently in direct opposition to all physiological method, and always utterly incomplete in relation to my objects, as the sequel will show.

The publications of the Wenzels, Tiedemann, and Rolando, which in some parts so strongly corroborate my views, took place at later dates —that of the first in 1812, those of the second in 1816 and 1821, and those of the third (the more recent ones here quoted) in 1822, 1824 and 1829; all of which are carefully referred to, when necessary.—The miserable plagiarisms of Bell and Magendie were later still.

The advantages to be derived from this method are, that a more complete view even of the anatomy of the brain than any previous one,

will be presented to the reader,—that no vague imputations of inaccuracy can be made,—that the facts will be indisputable,—that the conclusions will alone remain for investigation,—and that it will not be easy to treat even them unfairly.

On the anatomical characters of the writers from whom I derive support, and of some whose support I decline, I may here make a few observations.

Soemmerring may be regarded as the father of our more accurate cerebral anatomy, especially as relates to the proportions of parts.

Reil has done more than any other writer as to the fibrous structure; but, on many occasions, he grievously abandons that method for which we are so inexpressibly indebted to him: as when he describes congeries and plates of fibres as an insulated organ — the medullary capsule, for instance, or substance immediately enclosing the outer portion of the anterior striated body, and the external part of which is the surface supporting the convolutions of the island.*

The Wenzels have done most as to the proportions of parts; but they give too little atten-

* In quoting from Reil, I have generally followed Mr. Mayo's translation, because the original has only of late fallen into my hands, and I have had time hastily to refer to it only for the passages which most strongly corroborate my own views, and of which I have thought it right to give a literal translation.

tion to internal structure, and frequently bestow too much on matters of inferior value.

Tiedemann isad mirable so far as he goes; but he might perhaps have bestowed more attention upon the development of minuter parts in the fœtal brain.

Among recent anatomists, Rolando appears to me to have done most in following up the method of Reil. He has shown us the layer of the valley of Sylvius forming the island, and its subjacent brown substance, and the layer under these which gives origin to the greater number of the convolutions of the lateral surface, as both distinct from the layer formed by the fibres of the peduncles placed mesially to them. He has also shown that, on the internal surface of each hemisphere, and over the great commissure, there are, not one, but two orders of fibres and convolutions, which are placed mesially in relation to that of the peduncles. He has, moreover, traced more extensively the bundles of the external geniculate body, the anterior commissure, and the perforated plate.

Rolando, however, departs sadly from the true method of tracing the cerebral fibres, when, after removing the layers of the valley of Sylvius and of the vertical convolutions, and some of the brown substance of the external portion of the anterior striated body, he describes in the

lateral aspect of the latter a ganglionic appearance (la tessitura di un ganglio), in which are seen three concentric layers consisting of radiating fibres; for even the sections of Vicq d'Azyr show that in this case he contemplates the mere cut extremities of various layers of fibres.

Flourens owed his momentary reputation to a most impudent robbery, in which he was abetted by the ridiculous vanity of his countrymen, several of whom have for years been strutting about like daws, and chattering in borrowed feathers.—What a pity that a people capable of such great and glorious things, should disgrace themselves by such little ones.

As a specimen of the care and accuracy of M. Serres, it is only necessary to mention that he has given from Rolando a lateral view of the oblong process in man, as that of a goat!

The most interesting parts of Magendie and Desmoulins' book on the vertebrata are the chapters copied from Rolando—but in such a way that no trust can be put in them.

To these the work of Vicq d'Azyr was greatly superior. It did not indeed fulfil the purpose of his patrons, D'Alembert and Condorcet, for which neither the man nor the method were suited. But its sections have furnished many indications to the followers of better methods, and it furnishes many still.

CHAPTER II.

STRUCTURE AND FUNCTIONS OF THE FUNDAMENTAL PARTS.

SECTION I.

ENUMERATION OF THESE PARTS, AND PREVIOUS STATEMENT OF DOCTRINE.

TIEDEMANN has shown that the parts within the skull which are the very first to be discovered in the human embrio, are its spinal cord, the oblong process, the cerebral peduncles, the anterior striated bodies, the hemispheres, the posterior striated bodies, the four tubercles, and the cerebel.

Even in the second month, Tiedemann observed all these parts, but saw no trace of the other parts of the brain, particularly of the great commissure, arch, transverse ring, &c.

These fundamental parts are, moreover, the longest to be found as we descend among the

classes of animals, in which other parts gradually disappear.

Birds present two anterior masses (inferior lobes of the brain), two tubercles, cerebel, and oblong process. Amphibia also present the former five. And these are the most constant in fishes.

These, therefore, are the original, fundamental, and most important parts of the brain.

Now, it is remarkable that, though Tiedemann's work was not then published, these were precisely the parts through which my dissections of the brain, unaided by any hardening process, enabled me, twenty-five years ago, to trace the general course of the nervous fibres.

As these parts are, generally speaking, composed of two substances—a white and a brown substance, I shall especially treat of the arrangement of the first, to which the second is evidently subordinate.

In the Preface, I have quoted the passages from my own Papers published so far back as July 1809, in which I distinctly stated the course of the nervous fibres and their action, through the brain and cerebel, from the anterior to the posterior spinal roots. — This I again quote, in order that it may, throughout the confirmations by other anatomists, be distinctly in the reader's mind.

"The course of the actions in the other matter, the medullary [or white], is precisely the same with that of the structure itself, as I have described it. For, it is evident, that two species of action take place through this structure — one obviously advancing from the organs of sense toward the sensorium commune [brain], and another returning from the sensorium commune to actuate the muscles and produce locomotion. Now, it does not accord with the distinctness of natural operations to suppose, that these motions, in opposite directions, take place through one and the same series of particles. It is far more accordant with that distinctness, to suppose, that they take place through different series. And this becomes confirmed, when we observe that circuitous course of the medullary fibres of the brain, which, in this Paper, I have described, the double columns of the spinal marrow [cord], which have never hitherto been traced in connexion with that general course, and the double origins, as they are termed, even of the encephalic nerves [those of the head], which I have here pointed out. Nature, thus, presents to us the double means by which this double operation is effected.

"But it may be questioned, by which nerves, columns and cerebral masses, the action ascends to the brain, and by which it descends to

the muscles. Fortunately, here nature also directs us. Several nerves of mere sensation [the olfactory, &c.] join the anterior masses; hence, they must be the ascending: one nerve [at least—the internal oculo-muscular*] of mere motion proceeds from the posterior masses; hence, they must be the descending: for sensation, as already said, must ascend to, and volition must descend from the sensorium commune [brain].

"Thus, then, it seems to be proved that medullary action commences in the organs of sense; passes, in a general manner, to the spinal marrow, by the anterior fasciculi [bundles] of the spinal nerves, which are, therefore, nerves of sensation, and the connexion of which with the spinal marrow or brain must be termed their spinal or cerebral *terminations;* ascends through the anterior columns of the spinal marrow, which are, therefore, its ascending columns; passes forward through the inferior fasciculi of the medulla oblongata [oblong process], and then through the crura cerebri [cerebral peduncles]; extends forward, outward and upward, through the corpora striata [anterior striated bodies];

* The writer might have said the general oculo-muscular, the external oculo-muscular, the facial, &c. which penetrate and pass through the anterior masses.

and reaches the hemispheres of the cerebrum itself. This is the course of its ascent to the sensorium commune.

"From the posterior part of the medulla [white matter] of the hemispheres, it returns by the thalami [posterior striated bodies], passing backward, inward, and downward; flows backward in the fasciculi under the nates and testes [four tubercles]; backward and upward through the processus cerebelli ad testes or anterior peduncles of the cerebellum; and thus reaches the medulla of the cerebellum itself.

"From the cerebellum [by its inferior peduncles and the restiform bodies], it descends through the posterior columns of the spinal marrow, which are, therefore, its descending columns; and expands through the posterior fasciculi of all the nerves, which are therefore the nerves of volition, and the connexions of which with the spinal marrow or brain must be termed their spinal or cerebellic *origins*. This is the course of its descent from the sensorium commune toward the muscular system."

This, after the lapse of six years, was repeated and enforced in Thomson's "Annals of Philosophy," for July and August, 1815, where the doctrine was summed up as follows.

"The leading heads, then, of this new system of the intellectual functions, are as follows:—

"1. That the nerves of sensation arise in the organs of sense, and by means of the anterior fibrils, terminate in the anterior columns of the spinal marrow.

"2. That those nerves of sensation which do not terminate in these columns, pass directly to the cerebrum.

"3. That the anterior columns of the spinal marrow terminate also in the anterior part of the cerebrum.

"4. That these nerves and columns are sensitive or ascending nerves and columns.

"5. That it is in this way that sensation becomes perception, and that are excited in the cerebrum the [various] faculties, &c.

"6. That the cerebral influence passes to the cerebellum by means of the corpora striata posteriora or thalami [posterior striated bodies], the anterior peduncles of the cerebellum, &c.

"7. That the cerebellum is the organ which gives impulse to all muscular motion, voluntary and involuntary."—It should have been, to all voluntary motion.

"8. That the posterior columns of the spinal marrow originate in the cerebellum.

"9. That from the cerebellum arise also several nerves of volition.

"10. That those nerves of volition which do not arise directly from the cerebellum, spring

from the posterior columns of the spinal marrow by means of the posterior fibrils.

"11. That these nerves and columns are the motive or descending nerves and columns.

"It appears, then, that there is a species of circulation in the nervous system, of which I have sketched the general course, as curious and admirable as that which exists in the vascular (the centre of the one being the heart, of the other the head); and that there is scarcely any point of the body which this circle does not involve and rest on, since, from almost every point ascends impression to the cerebrum by a nerve of sensation, the anterior nervous roots, and the anterior columns of the spinal marrow; and to each returns expression from the cerebellum by the posterior columns, the posterior nervous roots, and the nerves of volition."

I shall, in the following sections, confirm these statements, by placing in the same (I may now call it systematic) order, the detached, dispersed, unsystematized, and unbiassed, facts of Reil, Tiedemann, Rolando, &c.—As these are mere facts, free from all reasoning on functions, no stronger support can, I imagine, be given to physiological doctrines.

SECTION II.

STRUCTURE AND FUNCTIONS OF THE ASCENDING PARTS.

That sensation must be communicated to the brain by nerves in which the action is ascending or toward the brain, is so obvious as not even to admit of elucidation.

That the anterior bundles of the spinal nerves are their ascending bundles, and the anterior columns of the spinal cord are its ascending columns, is proved by the following among other considerations.

1st. Sensation must precede, not only motion, but perception and intellect, in conformity with the truth "nihil in intellectu quod non prius in sensu;" and accordingly the anterior roots of the spinal nerves join the anterior columns of the spinal cord, and these run up and expand into the brain, which acquires superadded parts and a general increase with the increase of perceptive and intellectual powers, and appears therefore to be their organ.

2dly. While the anterior columns, by means of the pyramidal bodies and cerebral peduncles, go directly to the anterior part of the hemispheres, so do the olfactory, optic and auditory nerves, as is evident from the inner termination of the olfactory and the first termination of the optic (which ascends from its commissure) both join-

ing anterior parts of the hemispheres,* and from great injury of the hemispheres instantly destroying vision and hearing, while it does not materially affect motive power. Now, of all these nerves, we know that the impressions must be ascending, for they are nerves of sensation alone. If, then, ascent and descent, or sensation and volition be respectively communicated by the spinal columns, the former must be communicated by those columns of which the prolongations are joined by nerves of sensation.

3dly. The development of organization corresponds with the activity, the intensity or the permanence of functions. Now, in the fœtus, all these anterior parts (columns, pyramids, peduncles, and hemispheres) are developed before the posterior, as the facts quoted in the sequel from Tiedemann, prove: correspondingly, ascending action or sensation absolutely must precede descending action or volition. On the contrary, the posterior parts are not developed till some time afterward; and it is precisely at the completion of that first feeble development of the posterior parts, as the facts quoted in the sequel from Tiedemann also prove, that the first motions of

* So also do other terminations of these nerves, as will be shown in the sequel.

the fœtus are felt.—It is scarcely possible to have a more decisive proof that the anterior nerves, columns, and their prolongations upward, are those of sensation.

4thly. The anterior nerves and columns are the least liable to pain; and it appears to be a law of the system, that all parts of specific sensation are unsusceptible of pain, as is the case with the olfactory, optic and auditory nerves — nay with the centre of all sensation, the hemispheres and great commissure of the brain.* Hence again the anterior nerves and columns must be those of sensation; and if they be in a slight degree affected by pain in any case, as Magendie and others assert, it is probably owing to the minuter nerves of their vessels, &c.

5thly. In living animals, in whom motions can be excited, it is by impression on the anterior nerves and columns alone, that sensation can be propagated either upward to excite the production of voluntary action, or through the spinal cord to produce involuntary action. That these artificial impressions are really propagated upward through ascending and sensitive nerves and columns, and that the consequent impulse to motion is then propagated down-

* An ample exposure of this truth may be found in the Preface.

ward from the cerebel, or that it otherwise passes through the ganglia or commissures of the spinal cord, is rendered evident by the fact, that, in all the higher animals, the connexion of the irritated nerve with the spinal cord is indispensable to the motion of the muscles.* Thus motion is excited by these nerves and columns, because they are those of sensation.

This doctrine, as we proceed, will receive many verifications, both from connected views and from the labours of others.

Beginning, then, with the lower nerves or those which join the spinal cord, I have already shown that the two great branches of each, which supply the various parts of the body and limbs, are formed by about half the fibres of each corresponding root crossing between the fibres of the other root toward the opposite branch, while the other half of each root runs onward in the branch of the same side; a rather greater number of fibrils, however, passing from the posterior root to the anterior branch than from the anterior root to the posterior branch.

The anterior roots of the spinal nerves are

* There is little resemblance between this case and that in which, in a detached limb, involuntary or automatic actions are excited by forcing the nervous globules into muscles by means of pinching successive portions of a nerve, always advancing from the portion last pinched nearer to the muscles excited.

distinguished from the posterior ones by being finer and more numerous; and this has been the subject of much observation and conjecture. The truth, however, which will be established here, that the anterior roots, belonging to sensation, ascend from innumerable points of the skin, while the posterior, belonging to volition, descend to a comparatively small number of muscles in which they are scantily distributed, explains this difference between them.

In the anterior columns of the spinal cord, then, terminate the anterior roots of all the spinal nerves.

If now, the sides of the anterior median furrow of the spinal cord be separated, we observe a cribriform surface which seems to consist of transverse fibres, which are probably the commissures of these anterior roots.

The anterior columns themselves passing through the oblong process, cerebral peduncles, and anterior striated bodies, terminate in the hemispheres of the brain, as will now be shown.

The two pyramidal bodies, forming the anterior bundles of the oblong process, and being the continuation of the anterior columns of the spinal cord, present, until the third month, as Tiedemann informs us, a broad and plane surface, as in fishes, reptiles and birds, because

the pyramidal eminences are not yet developed on their surface.

In the fourth month, some of their fibres cross before forming the pyramidal bodies; and in doing so, Tiedemann says, he observed fibres which proceed from behind forwards, some from the right bundle to the left pyramid, others from the left bundle to the right pyramid.

Mr. Mayo has shown, in his plates, that the fibres which both Tiedemann and Rolando describe as coming to the pyramids from within or centrally, are those which form, by reciprocal crossing, the inner sides of the pyramids or those next the mesial line.

To the same writer, we are indebted for observations which, while they show the uninterrupted and direct course of the other bundles of the oblong process and spinal cord, explain more minutely the disposition of the fibres composing the pyramids. "The superficies of the medulla," he says, "when hardened, is found to tear into longitudinal filaments, in the same manner as the spinal marrow. At the back part, these run uninterruptedly into the longitudinal fasciculi of the chord; so likewise laterally; but not so at the fore part. The longitudinal fasciculi, of which the anterior pyramids are formed, when they approach the spinal chord, spread in three directions: the exterior filaments bend round

towards the back part of the medulla oblongata; the middle filaments descend straight, so as to be continuous with the anterior filaments of the spinal chord; but the inner portion of the anterior pyramid, constituting by far the larger part, throws itself in three or four broad bands obliquely across the median furrow, to the opposite half of the chord, decussating the corresponding series of fasciculi, and becoming continuous thus with the centre of the opposite half of the spinal marrow. As I have found this disposition of parts, not merely in man, but in the ox, the horse, the ass, the monkey, the dog, the kangaroo, the porpesse, I entertain no doubt that it exists in all mammalia."

As to the exterior filaments which Mr. Mayo describes as bending round toward the back part of the oblong process, I have some doubt of their belonging to the pyramids, as they are nearly in the situation of the broad and thin sheet of white fibres which I described in 1809—as being first seen immediately below the grey band of the auditory nerve, and appearing to emerge from under it,—as passing in a curved direction downward and backward, embracing, at this part, the oblong process, just as the ring does above, and terminating by the sides of the longitudinal bundles between the anterior pyramids and the olivary bodies,—as not running in contact with the cerebellic ring, or the narrower

band under it,—and as seeming to form origins of the glosso-pharyngeal, and pneumo-gastric nerves. This broad and thin band Rolando described twenty years afterwards, namely, in 1829, under the name of arciform filaments.

On the fifth month, Tiedemann says, the pyramids begin to form a projection on the outer side; and in the seventh, form very distinct eminences; each being three lines long and one broad; and the pyramidal bundles having crossed before forming these eminences.

Of their further progress, Reil states that the pyramids appear to consist of parallel white bundles which form two fibrous cylinders; that, in their ascent, they make a distinct channel in the olivary bodies, and are internally in mutual contact; that they contract just before they enter the transverse ring; that, towards the posterior margin of the transverse ring, they separate from each other and from the adjoining bodies, and plunge, as separate cylinders, into that substance; that in it, their fibres are again spread out, and form several layers, interwoven, at right angles, with the transverse fibres derived from the cerebel [this Tiedemann observed in the eighth month, and he accordingly says their longitudinal fibres crossed and mutually united, in many points, with the transverse fibres of the ring]; that all their bundles, however, do not appear to pass through the ring, as some

ascend behind it, and join with those of the fillet; that, from their entrance into the ring upwards, they are continually enlarging and diverging, but to a more remarkable degree after they emerge from that body; and that beyond the ring, the white bundles derived from the pyramids continue to ascend, forming the anterior and inferior surface of the peduncles, external to which are seen the fillet and the geniculate bodies on either side.

The view given of the course of the ascending bundles, in the last paragraph, is so far quite connected; but it must now be broken by some associated circumstances, which must be understood before we proceed in tracing the remainder of the course of these bundles.

I would first, then, notice here, parts not merely connected, but, at this point, continuous with the system now described. These are the geniculate bodies or corpora geniculata.

The geniculate bodies are two in number on each side, namely an external and an internal, are in form globular, in colour grey behind and white before, and expand themselves over the cerebral peduncles, especially along their outer margin.

Of the external, Rolando says that, with one bundle of fibres, it extends under the optic track to the optic commissure [physiologically considered, he should have said — receives a

bundle from the optic commissure, for this is evidently one termination of the optic nerve], and with another passes between the optic track and the peduncles according to the direction of their fibres,* [the latter being evidently the continuation of the optic nerve from this kneed or geniculate body to the hemispheres]. Of the latter, he accordingly says elsewhere, that from this tubercle there arises a bundle of fibres, which passing under the optic track, bends over it like the fibres of the peduncles, and extends with them to the posterior and inferior region of the hemispheres.†

As to the internal geniculate body, there are reasons, which will be afterwards assigned, for supposing that it similarly receives a bundle from the olfactory nerve; and after a similar bend, it sends its continuation to join the peduncles. Reil accordingly says, that the second layer of the posterior striated body is a production of the internal geniculate body,

* Questo tubercolo con un fascio di fibre si estende sotto la fascia ottica sino all' area quadrata, e con un altro passa tra la fascia ottica ed i pedoncoli secondo la direzione delle sue fibre.—*Della Struttura degli Emisferi Cerebrali*, p. 43.

† S' innalzava un fascio di fibre, che passando sotto la fascia ottica su questa se piegava come le fibre dei detti pedoncoli, ed insieme si estendevano per la regione posteriore ed inferiore degli emisferi.—*Ibid.* p. 22.

which expands either way. seems to adhere with its outer part upon the outer margin of the cerebral peduncle, like a band surrounds it in the outer portion of the anterior striated body, and, radiating forwards, goes towards the fibrous cone.*

Such are the parts which, at this point, are not merely connected, but continuous toward the hemispheres, with the system now described. — We next consider those which are connected, but not continuous, with it, and which lie, not laterally like these, but above or within it.

"*The upper surface of the peduncles,*" Reil observes, "is immediately covered by black substance, which is interposed between it and the bundles above it (die haube). [The cerebral peduncles, properly so called, are those bundles only which pass before or below the black substance.] Over it and further forward," he says, "it *is covered* by the four tubercles and *by the posterior striated bodies,* and finally *its an-*

* Die zweyte Lage ist eine Production des innersten corporis geniculati welche sich zu beiden Seiten ausbreitet, mit seinem äusseren Theile sich über den äusseren Rand des Hirnschenkels wegzuschlagen scheint, und wie ein Band denselben in der Kapsel des grossen Hirngangliums umfasst, vorwärts strahlt und gegen den Stabkranz geht.— *Archiv für die Physiologie, Neunter Band,* p. 154.

terior part above and below is enclosed by the inner and outer portions of the anterior striated bodies."*

This statement, I deem of the greatest importance; and I have put in italics the expressions which most strongly support the view I have taken as to the more intimate relation which the ascending bundles have to the anterior, than to the posterior striated bodies — a point which, it will subsequently be seen, Reil himself did not perfectly understand, because he altogether overlooked function.

So far, however, as this excellent anatomist goes, I quote him, as well as Tiedemann, because a combination of the very highest authorities treating only of facts in structure, is essential to perfect confidence as to the solidity of the basis on which rest the physiological doctrines of this work. Reference to the Preface, however, or to a previous extract in this section, will show that I briefly but most

* Seine obere Fläche wird unmittelbar von der schwarzen Substanz bedeckt, die zwischen ihm und seiner Haube liegt, und die Wurzeln des dritten Nervenpaars aufzunehmen scheint. Ueber dieselbe, und mehr vorwärts, bedecken ihn die Vierhügel und die Sehhügel, und am stärksten ist sein vorderer Theil unten und oben, nicht allein von der inneren und äusseren Portion des grossen Hirngangliums umringt, &c.—*Ibid.* p. 152.

clearly, traced both structure and functions five-and-twenty years ago.

"If," says Reil, previously and more in detail, "a transverse section be made of the peduncle before the transverse ring, we find in the section that the basis has a foliated structure, and that the bundles above it (die haube) have a less distinct organization, and in them we designate a circular field, which lies immediately over the basis. *The basis is properly alone the cerebral peduncle;* the bundles above are a foreign organization. It, like a half-moon, surrounds these bundles, &c. *Upon the basis rest the other bundles, namely* all the parts situated at the floor of the fourth ventricle between the lateral peduncles of the cerebel, also the black substance, the tubercles, *the posterior striated body,* and, lastly, the inner portion of the anterior striated body."*— This is a valuable view of the relations of these parts.

* Schneidet man die Hirnschenkel vor der Brücke durch, so findet man im Durchschnitt einen blätterigten Bau der Grundfläche, aber die Haube hat weniger Organisation, und in ihr zeichnet sich ein kreisförmiges Feld aus, welches unmittelbar über der Grundfläche liegt. Die Grundfläche ist eigentlich nur der Hirnschenkel, die Haube eine fremde Organisation. Er umgiebt halbmondförmig die Haube, &c. . . . Auf der Grundfläche ruht die Haube nemlich alle Theile, die im Grunde der vierten Hirnhöhle zwischen beiden seitlichen Schenkeln des kleinen Gehirns liegen, ferner die schwarze Substanz, die Vierhügel, die Sehhügel und

Here the same important point — the more intimate relation which the ascending bundles have to the anterior, than to the posterior striated bodies, is again indicated; and it is surprising that, after this, Reil should have fallen into vague and inaccurate expressions respecting the relations of these bodies.

Exactly twenty years after my publication, Rolando observed that "*the white lamina of the peduncles* above the ring passes before the layer of black substance which divides it from the other anterior bundles of the spinal cord; that above that, it is again in contact with these bundles for some lines; that thence it *passes by the side of the posterior striated bodies and of the fibres which come from them;* and that leaving these where they bend to the region of the great commissure, it is in contact with white fibres which come from the raphe, with which it forms the convolutions of the internal margin of the hemisphere."* — Thus was this important point

zuletzt die obere Portion des grossen Hirngangliums, die unter dem Namen des gestreiften Körpers bekannt ist. — *Archiv für die Physiologie, Neunter Band,* p. 150.

* La lamina midollare dei pedoncoli appena sortita dalla protuberanza passa innanzi allo strato di sostanza nerastra, che la divide dai cordoni anteriori del midollo spinale. Al di sopra di questa si trova nuovamente a contatto per alcune linee coi cordoni suddetti; quindi passa a lato dei talami ottici, e delle fibre, che ne sortono. Lasciando queste ove si piegano per passare alla regione del

of structure distinctly acknowledged by Rolando.

The same writer shows that the anterior fibres from the peduncles bend upon the anterior commissure, and seem to unite with its olfactory bundle, whence they go to form the orbicular convolutions which occupy the middle of the frontal region; that the middle fibres of the peduncles, having passed the external striated body, ascend to the vertex, and terminate in the convolutions at the superior margins of the hemispheres; and that posteriorly the fibres of the peduncles bend strongly around the optic tracks, together with the fibres of the external geniculate body, and thus pass to the occipital lobe and temporal lobes, and lose themselves in the posterior and inferior convolutions of those regions.

Tiedemann had previously stated that, toward the end of the third month, the peduncle commences along its external border (that of the striated body) to expand into the hemisphere, which, reflected inwards over this protuberance, forms thus the lateral ventricle, comprised between its summit and the internal surface of the hemisphere; that in the course of

corpo calloso, si trova a contatto colle fibre midollari, che vengono dal raphe, colle quali forma i processi enteroidei del margine interno degli emisferi. — *Della Struttura degli Emisferi Cerebrali*, p. 21.

the following months, the anterior striated bodies winding round the peduncles at the point where their fibres radiate in the hemispheres, gradually augment, and increase in the same proportion as these latter acquire thickness and a greater development; and that their anterior portion, the broader, dips into the anterior horn of the lateral ventricle; and the posterior, the narrower, plunges into the descending horn of the same cavity.

I do not adduce Reil's authority upon this point, because he speaks generally of the fibrous cone, in which he indiscriminatingly involves both the anterior and the posterior striated body. The matter, however, is already sufficiently clear.

The anterior and middle parts alone, Reil says, of the fibrous cone are enclosed between the two portions of the anterior striated body. And again—the striated body consists of two parts, one external, the other internal to the substance derived from the peduncle.

Rolando is of opinion that the anterior striated body should be divided into internal and external, because these are separated [except anteriorly] by the fibres of the peduncles and of the posterior striated bodies, and because their texture is different.

The internal portion of the striated body, of pyriform shape, is certainly, as he observes,

composed of a single and homogeneous brown substance, and it seldom or ever penetrates to the fibres of the peduncles which run externally; while the external portion is in some respects different.

The cavity containing the external portion of the striated body, lies also somewhat lower than the internal portion, presents the fibres of the peduncles above and the optic tracks below, and is covered externally by the hamular bundles and the white expansion of the vertical convolutions.

It is this which Reil improperly describes as the capsule of the outer portion of the anterior striated body, having three surfaces—an outer wall, an inner wall, and a floor. As in doing so, however, he indicates some important relations of parts, we may briefly follow him in this view.

Reil considers the floor of the capsule as consisting of the medulla incognita, of the perforated plate, and of the bases of the convolutions which are in contact with the root of the olfactory nerve, and as extending inwards toward the apex of the anterior fold of the superior commissure, backwards toward the posterior margin of the cerebral peduncle, and outward to the hamular bundles. The outer wall of the capsule, he considers as composed of the hamular bundles; the inner wall, as composed of the outer surface of

the fibrous cone; and these two, as meeting at an acute angle at the upper margin of the outer part of the striated body, decussating each other and being there interwoven.

Every where, says Reil, but at its fore part, the external portion is shut in by its walls. Anteriorly it is perforated by the anterior commissure; gives support to the optic commissure; is continuous with the infundibulum; and, being prolonged, surrounds the anterior pillars of the arch and the pisiform eminences; overlays the walls of the third ventricle; and unites the posterior striated bodies, under the form of the soft commissure.

He adds that when layer after layer is raised from the outer wall of the capsule, an appearance is met with as if fibres radiated from the upper margin of the grey matter; and that white fibres arise from the whole of the grey substance, the direction of which is towards its upper margin, where they plunge into the substance of the inner and outer walls of the capsule.

And Rolando observes that the ascending fibres of this which he terms the external striated body are intimately connected with the anterior commissure, the hamular bundles or olfactory arch as he terms it, the optic track, the fibres of the peduncles, and the external root of the olfactory nerve.—The central nucleus or

lower fibres are continuous with the perforated plate.

The anterior striated bodies, it may be observed, exist in the brain of mammiferous animals; and their development is proportioned to that of the hemispheres.

Tiedemann says, that the fibres which radiate in the hemispheres [for we have now traced them so far, pointed out their real connexions, and disembarrassed them of those wrongly imputed to them] proceed, at from fourteen to fifteen weeks, laterally, forward, and backward, but all from below upward, and are then reflected inward to form the roof of the lateral ventricles;—that, in the sixth month, the expansion of the fibres of each peduncle in the hemispheres becomes very distinct; that, radiating in the hemispheres, they proceed first upward, then, bending inward, form the roof of the lateral ventricles, and the superior surface of the hemispheres; that, descending afterward along the internal surface or commutual region of these latter, the anterior and middle, uniting with those of the opposite hemisphere, give origin to the superior commissure; while the posterior are confounded with the posterior pillar of the arch, and form the hypocampus or greater bend;—that, in the eighth month, this radiation becomes very evident on removing, at the commencement of the transverse fissure be-

tween the anterior and middle lobes, the exterior layer of unfibrous substance, and scraping this substance upwards with the flat handle of a scalpel, when the fibres which rise from the fissure of Sylvius, bending inwards over the lateral ventricle, cover this cavity like an arch, and, uniting afterwards to those of the opposite side, form the superior commissure.

Having thus followed the course of the ascending fibres, I cannot conclude better than in the words of Reil, who says—" The whole radiation, from the beginning of the pyramids to the end of the fibrous cone in the remotest convolutions is one undivided and dependent system."*—Reil erred only in including, in this organ, the posterior striated bodies, which maintained an inextricable confusion as to its functions and those of the brain in general. When we treat of the posterior striated bodies, all this will be still more clearly seen.

It is obvious, therefore, that, in 1809, I did not err in saying that " the medullary [white] matter may be traced as continued from the portions of many nerves which join the two anerior columns of the spinal marrow [cord], upward through these columns to the inferior fas-

* Die ganze Radiation von dem Ursprung der Pyramiden an, bis zum Ende des Stabkranzes in den vörderen Hirnlappen ist Eins, ein ungetheiltes und zusammenhängendes System.—*Lib. cit.* p. 147.

ciculi [bundles] of the medulla oblongata [oblong process], forward through the crura cerebri [peduncles], and forward, outward [backward] and upward through the corpora striata [*anterior striated bodies*] and the hemispheres of the cerebrum."

It is here not a little curious, as already mentioned, to observe, that the successive growth of these original, fundamental and most important parts, conforms with the course of action here pointed out.

Tiedemann states, that, at seven weeks, "the posterior surface of the spinal cord is open, and also the superior surface of the brain, through the whole extent of which, the canal of the former is extended."*

Even when these parts begin to close, the mode in which this is done and the relative thickness of parts of the walls of the cavities thus completed, still show the prior formation of the anterior parts.

Of the mass which ultimately becomes the four tubercles, Tiedemann says, that, in the fourth month, "its membranous walls rest on the cerebral peduncles, from which they receive some fibres which are reflected upward and in-

* Die hintere Fläche des Rückenmarks, so wie die obere des Hirns ist offen, und unverkennbar setzt sich der Rückenmarks-Kanal über die ganze obere Fläche des Hirns fort.—*Anatomie und Bildungsgeschichte des Gehirns*, p. 14.

ward toward each other, so that they unite: the thickness of these walls was one line and a quarter at the inferior part or near their commencement, but on the contrary, scarcely one-third of a line at the superior part.*

"The membranous walls of the hemispheres were, on the outer side, in front, and along the anterior striated bodies, the thickest: at the internal part, on the contrary, they were the thinnest, being scarcely one-fourth of a line thick.†

"The fibres which radiate in the hemispheres from the outer side of the anterior striated bodies, proceed laterally, forward, and backward, but all from below upward, and then bend inward, to form the superior vaulted roof of the lateral ventricles, and redescend afterwards, along the internal surface of the hemispheres, toward the pillars of the arch. . .The hemispheres of the brain are therefore but membranes

* Die membranartigen Wände der Vierhügel sitzen auf den grossen Hirnschenkeln auf, von denen sie Fasern erhalten, und krümmen sich von aussen nach oben und innen gegen einander um sich zu verbinden. Die Membranen sind unten, nahe an ihrem Ursprung 1¾ Linie dick, oben hingegen kaum ⅓ Linie.—*Ibid.* p. 32.

† Uebrigens sind die membranartigen Wände der Hemisphären nach aussen vor und neben den gestreiften Körpern am dicksten, nach innen hingegen sind sie am dünnsten, kaum ¼ Linie dick.—*Ibid.* p. 34.

reflected inward and backward, which are produced by the fibrous radiation of the cerebral peduncles. Hence, then, it is also conceivable why the walls of the hemispheres are thickest on the outer side of the anterior striated bodies, and why they are thinnest on the inner side."*

But it is useless to multiply illustrations of this kind. If there be one great truth to be derived from Tiedemann's labours on the fœtal brain, it is that the anterior parts of the cerebro-spinal system are formed before the posterior.

Thus, there is a perfect correspondence, in this respect, as to the growth and formation of these parts.—All *the anterior parts are first formed;* and this, even without the other arguments already given (as observed by Reil, they

* Die an der äussern Seite der gestreiften Körper in die Membran der Hemisphären ausstrahlenden Fasern der Hirnschenkel laufen seitwärts, vorwärts und rückwärts, stiegen nach oben, und krümmen sich einwärts um die obere gewölbte Wand der Seitenventrikel zu bilden, und senken sich dann wieder an der inneren Fläche der Hemisphären gegen die Schenkel des Bogens (Crura fornicis) herab... Demnach also sind die Hemisphären des grossen Hirns von aussen nach innen und hinten umgeschlagene Membranen, welche durch die faserige Ausstrahlung der Hirnschenkel gebildet werden. Hieraus wird es denn auch begreiflich, warum die Wände der Hemisphären nach aussen neben den gestreiften Körpern am dicksten, und warum sie nach innen am dünnsten sind.—*Ibid.* p. 35.

are one organ), would render it probable that they serve similar purposes — that the motions within them are similar and continuous — that *these motions are the first of those essential to the nervous system* — that, in fact, *they are the ascending motions;* the descending subsequently causing the development of the posterior parts of the brain and spinal cord.

That it is thus perceptive and not muscular motions which are dependent on these parts, may be further supported even by Magendie's experiment, of which he says, "I divided the two pyramids entirely across, about the middle of their length, and no apparent derangement of the motions followed: I merely *thought* I could perceive a *little* difficulty in their progression forwards."

Thus far, then, it must, I think, be evident, that, with regard to the functions of these parts, I was vindicated in stating, in 1809, that "medullary action commences in the organs of sense; passes, in a general manner, to the spinal marrow, by the anterior fasciculi of the spinal nerves, which are, therefore, nerves of sensation, and the connexions of which with the spinal marrow or brain must be termed their spinal or cerebral *terminations;* ascends through the anterior columns of the spinal marrow, which are, therefore, its ascending columns; passes forward through the inferior fasciculi of the

medulla oblongata, and then through the crura cerebri; extends forward, outward [backward] and upward through the corpora striata; and reaches the hemispheres of the cerebrum itself. This precisely is the course of its ascent to the sensorium commune."

The nerves and nervous bundles are the sole means of such action, and it appears that different sensations are conveyed by them, in consequence of different impressions being made on them by different external objects.

That the nervous matter is so gross as to be affected by pressure is evident from this, that the compression of a nerve excites a muscle to act; and it is indeed also proved by actual demonstration. It does not even appear, that great subtilty is necessary in these motions of the nervous substance.

Prochaska has shown that this substance consists of globules which adhere to each other; float in water, and are not separated by it; are arranged irregularly in the brain, but in longitudinal rows, separated by partitions of neurilema, in the nerves. These globules will of course roll on each other in flexion, and maintain an analogy with the simplest particles of external matter, which many considerations indicate to be also globular.

But it appears also, that these globules are more or less moveable longitudinally in such a

manner, that pressure, or impression, on one end of a series, will at least cause projection at the other; and this is proved by a cut nerve presenting its numerous prominences. It is indeed only in this way, that organic action can be performed with such velocity. Thus, one ball impinging upon the nearest one of a long series of them, moves the most distant in a very evident manner.

It is only in this way, that we can account for the rapid motions produced by the nerves.

It appears to be upon this principle also, that the motions of the nervous substance are not evident; for in it motion being in direct lines, as in the series of balls, must, in its course, be less apparent; but will gradually become conspicuous in the muscles, because they depart more from the right line and are undulated; and must become large and evident in the bones, because they depart most from the right line, and form actual levers.

The slightest consideration will show how well adapted these globules are to receive the impressions of objects.—"When the idea of solidity is excited," says Dr. Darwin, "a part of the extensive organ of touch is compressed by some external body; and this part of the sensorium, so compressed, exactly resembles, in figure, the figure of the body that compressed it. Hence, when we acquire the idea of solidity,

we acquire at the same time the idea of figure; and this idea of figure, or motion of a part of the organ of touch, exactly resembles in its figure, the figure of the body that occasions it; and thus exactly acquaints us with this portion of the external world."—But we shall afterwards speak of this in detail.

SECTION III.

STRUCTURE AND FUNCTIONS OF THE CEREBRAL PARTS.

Before speaking of the functions of these parts, we may briefly notice their progressive development in animals.

In fishes (and it is not very different in reptiles), by the arrangement of the portions of the brain behind, and not below, each other, it approximates in form to the brain of the human embrio during the earlier periods of existence.

In quadrupeds, almost as in birds, there is found on the lower surface of the hemispheres a white fibrous connexion between the olfactory tubercles and the inferior lobe of the brain; but it is short, and therefore proves the slight extension of the anterior lobes which, when developed, require the longer extension of the olfactory nerves over their inferior surface toward the middle lobes.

The size of the human brain, say the Wenzels, from the period of conception till the seventh year of life, advances continually toward its full magnitude.*

To this Dr. Milligan enables us to add, with regard to the external head, that hatters add the two diameters together, and take their arithmetical mean for the diameter of hats ; and as the number of heads they measure is immense, and they themselves are void of all theory, the following table, obtained from an eminent manufacturer, and exhibiting the mean diameters of the external head, at the different ages, may assist in comparing the growth of the brain with that of the head:

TABLE OF MEAN DIAMETERS OF HEADS.

For a child of 1 year	$5\frac{5}{8}$	
———— 2 years	$5\frac{7}{8}$	
———— 4 years	$6\frac{1}{8}$	
———— 7 years	$6\frac{5}{8}$	; it then varies little till 12.
———— 12 years	$6\frac{3}{4}$	
———— 16 to 18 years	$6\frac{7}{8}$	
Adults	$7\frac{1}{6}$	; largest $7\frac{3}{4}$ to 8 inches.

Servants' heads are generally small, $6\frac{3}{4}$ to $7\frac{1}{4}$; Negroes' heads also are small.

Women's heads are more round than men's, and are nearly all of a size, varying from $6\frac{5}{8}$ to 7 inches in diameter.

* Magnitudo humani encephali a conceptione usque ad septimum vitae annum continuo et celeri satis gradu ad perfectam suam magnitudinem procedit. — *De Penitiori Structura Cerebri Hominis et Brutorum*, p. 254.

These measurements, if I mistake not, are from Scottish heads; and this is necessary to be understood, for in every country the average size of heads differs materially.

With regard to the size of the brain, however, the most important results are to be derived from its comparison with other parts of the nervous system. I shall therefore, translate as literally as possible the statement of the most important facts on this subject from the works of the profound observers of them.

Soemmerring* says, "The first and principal rule, which this plate [that of the base of the brain] excellently illustrates, regards the physical cause, evident to the eyes, why man far excels all other animals in the faculties of the mind. If, to solve this question, we examine all parts of the body, we find none except the brain, which in relation to the nerves joined to it, excels in magnitude the same part in brutes. Compare the brain of any animal with the human brain delineated in this plate, and you will certainly find none, which in relation to the nerves joined to it, possesses so great, so immense a brain." † And again,

* *Tabula Baseos Encephali.*

† *Ibid. p. 5.*—Primum et princeps dogma, quod optime hac tabula illustratur, circa rationem physicam, ipsis oculis cernendam, versatur; cur homo animi facultatibus longe omnia reliqua animalia superet? Si ad quaestionem

"Wherefore this statement will suffice, to make it understood of how much importance is the observation, that in no animal have I ever found a brain, which in relation to the nerves joined to it, approached the human brain in magnitude: and I have always seen that rule confirmed without any shadow of exception."* And he closes his comparison of animals in relation to the size of the brain and the faculties of the mind with this conclusion: "That man, by reason of the magnitude of his brain, in relation to the nerves joined to it, far excels all other animals; whence nothing greater than himself is generated, nor grows there aught similar or second to him."†

hanc solvendam omnes corporis partes perlustramus, nullam nisi encephalum invenimus, qui ratione nervorum ipsi iunctorum habita, magnitudine sua eandem partem in brutis superat. Compara encephalum cuiusvis animalis cum humano encephalo in hac tabula delineato, et nullum profecto invenies, quod ratione habita nervorum ipsi iunctorum tam magno, ne ingenti dicam, gaudeat encephalo.

* *Ibid. p.* 6.—Quare hoc unum satis erit dictum, ex quo intelligi possit, quanti sit momenti ista observatio: in nullo animali me unquam reperiisse encephalum, qui ratione nervorum ipsi iunctorum habita, ad humanum magnitudine accedat, semperque sine ullo exceptionis vestigio ratum illud dogma vidisse.

† *Ibid. p.* 11.—Hominem, ob magnitudinem encephali sui, ratione nervorum ipsi iunctorum, animi facultatibus, omnia reliqua animalia longe superare; unde nil majus generatur ipso, nec viget quicquam simile aut secundum.

The Wenzels say "That in man exists a proportionally far greater mass of brain than in mammalia, or that that part of the mass of the brain which surrounds parts situated internally, peculiarly formed, or individual, is in man proportionally larger than in mammalia."*

Tiedemann says, "By our researches, therefore, is confirmed the rule proposed by the celebrated Soemmerring, that the human brain is the largest in proportion to the bulk of the nerves."† Again, "It hence follows that, among the mammalia examined by us, man enjoys the greatest brain, or that in his brain is accumulated the greatest part of the white and sensorial substance, which relates to the bond by which the functions of the nerves are connected with the faculties of the mind. Man similarly in mental qualities, power, and genius, far surpasses and excels all animals. The dignity of the brain, moreover, in the functions of sensitive life, appears manifest, if we consider the differ-

* *Lib. cit. p.* 259. — Homini pro ratione longe plus massae cerebri inesse, quam mammalibus, sive illam massae cerebri partem, quae in interiore cerebro sitas, peculiariter formatas, sive individuas partes ambit, in homine pro ratione majorem esse, quam in mammalibus.

† *Icones Cerebri Simiarum et quorundam Mammalium Rariorum, p.* 41.—Confirmatur ergo nostris disquisitionibus dogma a celeberrimo Soemmerring propositum, humanum cerebrum pro ratione molis nervorum maximum esse.

ent orders of mammalia, for by so much as the evolution of the brain is greater, and by so much as its bulk is greater in relation to the nerves, oblong process, cerebel, four tubercles, pisiform eminences, and pituitary gland, by as much are greater sagacity and docility observed in mammalia. The simiæ and the phoca are next to man in magnitude of brain. The lemures, cetacea, ruminantia, multungula, solidungula, feræ and bradypoda follow. The smallest brain exists in animals of the order glires, didelphes, edentata and chiroptera."* And again, "Therefore the brain of mammalia, although its structure greatly approaches to the human brain, is

* *Ibid. p.* 47.—Ex his sequitur: Hominem inter mammalia a nobis examinata maximo gaudere cerebro, vel in ejus cerebro maximam partem substantiae medullaris ac sensorialis accumulatam esse, quae ad vinculum spectat, quo ipsae nervorum functiones cum animi facultatibus nectuntur. Homo pari modo animi dotibus, vi atque ingenio omnia animantia longe superat et antecellit. Manifesta praeterea apparet cerebri in functionibus vitae sensitivae dignitas, si ipsos consideramus diversos mammalium ordines; quo enim insignior encephali est evolutio, et quo major ejus est moles relata ad nervos, medullam oblongatam, cerebellum, corpora bigemina, eminentias candicantes et hypophysin cerebri, tanto major in mammalibus observatur sagacitas et docilitas. Simiae et phoca quoad magnitudinem cerebri Homini sunt proximae. Sequuntur lemures, cetacea, ruminantia, multungula, solidungula, ferae et bradypoda. Cerebrum minimum est in animalibùs ex ordine glirium, didelphium, edentatorum et chiropterorum.

much less in size."* And finally, "That in man the brain excels, and that on that evolution of the brain depends the highest excellence of man, the use of reason, cannot be doubted."†

It would have occupied many pages to translate here the numerous illustrations of this great truth which are furnished by the works of Soemmerring, the Wenzels and Tiedemann: it is in the power of any reader to refer to them for further details.

This truth is of the deepest importance; for as man excels inferior animals not only in proportional magnitude of brain, but in the number of parts of which the brain consists, in the bulk of individual parts, and in the number of fibres composing them, the conclusion is obvious, not only that its general magnitude is the essential condition of his superior intelligence, but that the number of its parts and fibres are similar conditions of the increased number of his intellectual functions.—But these matters, I shall afterwards consider in detail.

That this excellence of man in intellect depends on the cerebrum, or brain properly so

* *Ibid. p.* 48.—Mammalium encephalus ergo, licet fabrica ad humanum plurimum accedat, mole tamen multo est minor.

† *Ibid. p.* 55.—In homine praevalere cerebrum, summumque hominis bonum, rationis usum, ab ipsa maxima encephali evolutione pendere, haud dubitari potest.

called, in particular, is rendered evident by other considerations; for if we consider the proportion of the brain to other parts, it appears, that the size of the spinal cord and that of the brain are generally in an inverse ratio to each other in vertebral animals; and that in man the cerebel, as well as the four tubercles, become strikingly subordinate to the greatly developed hemispheres.

In conformity with this statement, Soemmerring observes "That another rule which this plate [that of the base of the brain] illustrates, regards the difference between the brain of man and brutes. The brain of any brute, beside the magnitude of the nerves joined to it, differs also greatly in the conformation and magnitude of individual parts compared with each other. By comparing this plate, therefore, with the brain of any animal, you will easily see:—1. That the brain is larger in man in proportion to the cerebel. In all the brains of mammalia, birds, reptiles and fishes, which I have dissected, I have always found the cerebel, in proportion to the brain, larger and otherwise situated than in man.* Even in the simia mandril, the cerebel is stated by Blumenbach to be large in proportion to the brain. But the simia sylvanus and the pigmy of Tyson appear to approach in this respect a

* The qualifications necessary to this statement, I have mentioned elsewhere.

little nearer to man. 2. That in man, the brain is larger in proportion to the spinal cord, or, in other words, the spinal cord is thicker in animals. Such is the case in the pigmy of Tyson, in my simia sylvanus, in the papio mandril of Blumenbach. In fishes, so large is the spinal cord, that the brain appears to be a very small addition to it."*

Many observations, however, seem to show that the cerebral hemispheres, taken as a whole, are developed in the direct ratio of the cere-

* *Lib. cit. p.* 12.—Alterum dogma, ad quod illustrandum haec tabula facit, circa differentiam inter encephalum hominis et brutorum versatur. Bruti enim cuiusvis encephalus, præter magnitudinem nervorum ipsi junctorum, summopere etiam conformatione magnitudine partium singularium secum invicem collatarum, differt.

Comparando ergo hanc tabulam cum encephalo cuiusvis animalis facile videbis : 1. Majus in homine esse cerebrum, pro ratione cerebelli. In omnibus, quos secui, mammalium, avium, amphibiorum et piscium, encephalis, semper cerebellum, pro cerebri ratione, maius et aliter situm reperi atque in homine. In ipsa simia mandril, cerebellum magnum esse pro cerebri ratione diserte asserit Blumenbach. Nonnisi simia sylvanus et pygmaeus Tysonis paulo propius hac in re ad hominem accedere videntur. 2. In homine cerebrum maius esse pro ratione spinalis medullae, sive, quod eodem redit, spinae medullam in animalibus crassiorem. Tali modo se habet in pygmaeo Tysonis, in simia sylvano mea, in papione mandril Blumenbachii. Piscibus tam magna est spinae medulla, ut cerebrum perparvum eius quasi additamentum videatur.

bellic hemispheres, and in the inverse ratio of its middle lobe.

Thus if the most extensive and profound views of comparative anatomy, sanctioned by names of the highest authority, are of avail, it will not be disputed not only that the general magnitude of the brain of man is the essential condition of his superior intelligence, and that the number of its parts and fibres are similar conditions of the encreased number of his intellectual functions, but that these higher functions are not those either of the cerebel or spinal cord, since the higher functions absolutely diminish with the encrease of those parts.

It is scarcely necessary to remark how completely fatal this last stated fact is to the hypothesis of those who, because they assert (erroneously) the dorsal nerves and columns to be those of sensation, and because the latter clearly join the cerebel, therefore assert also that the cerebel is the organ of sensibility. This, the cerebel must indeed be, if the posterior nerves and columns are those of sensation. The preceding fact, however, shows the reverse; for if the cerebel were the organ of sensibility, it would bear a direct relation to perception, which is indeed only another name for sensibility in the common sensorium; and the fact alluded to is, that the higher functions (which are mere combinations of perception and pro-

cesses to which it is subjected) absolutely diminish with the encrease of the cerebel.

This fact, I say, is fatal to that hypothesis; and is felt to be so. Therefore M. Magendie said "La disposition anatomique indique que le sentiment doit (consistently with his and Sir C. Bell's erroneous view) se diriger plus particulièrement vers le cervelet: mais (candour induced him to add) . . . les lésions du cervelet ne font point perdre la sensibilité"—as quoted at length in the Preface.

As M. Magendie there grants what the function of the cerebel is not, so he also grants what those of the cerebrum are not. He says "La soustraction des hémisphères n'emporte pas necessairement la perte du mouvement." He acknowledges that the cerebral hemispheres may be cut deeply into the different points of their superior surface, without any marked alteration of motion taking place; that even their entire removal, if not extended to the anterior striated bodies, produces no appreciable effect, except what may easily be referred to the suffering which such an experiment must induce; that the results which he has described, have been observed in quadrupeds, and especially in dogs, cats, rabbits, guinea-pigs, hedgehogs, squirrels; that he has seen, in a number of cases, birds run, leap, swim, when their hemisphere was removed, vision alone being extinguished;

that in reptiles and fishes, the removal of the hemispheres seemed to have very little effect upon their movements, the carp swimming with agility, the frogs leaping and swimming about as if they were quite untouched, &c., and that even the longitudinal section of the great commissure, and its removal, produce no additional effect upon the motions.

If, as already stated, the upper part of the cerebrum be removed in birds and quadrupeds, the animals appear stupified, of course, because perception is diminished or destroyed; but, when they are roused, locomotion is performed with steadiness and precision, because it depends upon another organ.

To complete the view of this subject, it is necessary to notice, more particularly than I have hitherto done, the apparent exception to this general law of the nonexcitability of motion by irritation of the brain.—Magendie says, "If indeed we remove from a young rabbit the two hemispheres with the great commissure and the anterior lobes, but touch not the anterior striated bodies, the forward movement is not developed; the animal preserves pretty nearly its gait, modified however in an evident manner by the pain and the hemorrhage; its position changes not even if we remove the grey matter which gives to the anterior striated bodies their form of the segment of a bent cone.

—What takes not place in consequence of the removal of the grey matter, fails not to occur by the removal of the white: from the moment that we begin to injure the latter, the animal evinces inquietude, tries to escape; however the removal of one only of the two anterior striated bodies leaves it still master of its movements, it directs them in various ways, and stops when it pleases; but as soon as both anterior striated bodies are, by a vertical section, separated from the posterior striated bodies, the animal throws itself forward and flies as if impelled by an irresistible power."*

* Si en effet vous soustrayez à un jeune lapin les deux hémisphères avec le corps calleux et les lobes anterieurs, mais que vous ne touchiez pas aux corps striés, le mouvement en avant ne se développe pas; l'animal conserve à peu près ses allures, modifiées cependant d'une manière évidente par la douleur et l'hémorragie; sa position ne change même pas si on enlève la matière grise qui donne aux corps striés leur forme de segment de cône recourbé.—Ce qui n'a pas lieu par la soustraction de la matière grise ne manque pas d'arriver par la soustraction de la blanche: dès que l'on commence à intéresser cette dernière, l'animal marque de l'inquiétude, cherche à s'échapper; cependant l'enlèvement de l'un des deux corps striés le laisse encore maître de ses mouvements, il les dirige en divers sens et s'arrête quand il lui plaît; mais aussitôt que les deux corps striés sont séparés par une section verticale, de la couche optique, l'animal se précipite en avant et fuit, comme poussé par une puissance irrésistible.—*Note sur les fonctions des corps striés et des tubercules quadrijumeaux, par M. Magendie.*

Now here, next to the remarkable difficulty of exciting motion by any irritation or injury of the cerebrum (for it is not until both anterior striated bodies are removed that any motion is excited), it is to be observed, that motion is caused only when all the parts are divided through which the whole of the ascending or forward cerebral motions naturally take place; that the motion artificially induced is in the same direction with these natural motions; and that it takes place only at that point of the brain at which, as will afterwards be shown, the brain is, by a reaction of the cerebel, through the transverse ring, subjected to the power of the latter—where in fact the function of the organ of perception gives place to that of the will and of voluntary motion.

Thus by showing what the functions of the brain and cerebel are not, Magendie virtually acknowledges what they are. For as perception with its combinations and the processes to which it is subjected on one hand, and volition on the other, are the general functions of the two great encephalic organs, it is evident, that if sensation, or rather perception, belong not to the cerebel, it must to the brain; and if volition belong not to the brain, it must to the cerebel.

These acknowledgments are interesting only as concessions from by far the cleverest asserter

of the doctrine which is an inversion of my own. But, as to the general function of the brain, we have already had the direct evidence furnished by the researches of Sommerring, the Wenzels and Tiedemann; and no addition to it seems necessary.

Previously to entering upon the more particular functions of the brain, it may be proper to observe, that though all ideas are derived from sensation, it does not follow that there should be an exact proportion between the senses and the succeeding intellectual operations, because the brain may be more and the organs of sense less developed.

Most of the obscurity of mental physiology, I must here observe, has arisen from the employment of words not understood. Matter and mind, they tell us, have no resemblance; for we have no conception how matter can think. Now here matter is a simple term or a well understood one, and mind or thinking an extremely compound one, or one which is ill understood, for it involves memory, imagination, &c. &c. Mind is an abstract term expressing all of these. It is not to be wondered, therefore, that the relations of matter and mind are not evident.

If one, however, of the most elementary operations of mind, one of the simplest acts of thinking, had been considered—if we had been told

that we have no conception how sentient matter can compare or determine the difference between two opposite impressions, a great portion of the obscurity would have been got rid of; and we should have come to a simpler question still—the difference between sentient and unsentient matter.

To proceed from compound to simple questions, is a happy approach to the right way of enquiry. It rids us of the appalling obscurity which results from mere complication. And in this case it relieves us of all the difficulties as to the differences between men and animals, and brings us to an element common to both.

We find that sentient matter in general has first vessels, which connect it in molecules and in a limited sympathy of action, or bestow upon it life. We find that this generally precedes sensibility, and is probably simpler in its nature. We next find that in general it has nerves, which unite the remotest of the molecules in one whole and in a more extensive sympathy of action, or bestow upon it sensibility.

This does not entirely remove our difficulty; but it shows that as matter advances from the unsentient to the sentient condition, there is a corresponding difference of organization. Even already, the probability, therefore, is that, on the difference of organization, depends the difference of function; for there can be no reason

why we should argue differently in this case from what we do in every other.

The question of mind is thus reduced to the question of sensibility, which may be found in polyps even, and which at least is in them associated with none of the complex relations and high faculties which result from these.

To proceed *gradatim*, the physical means of these operations may first be considered.

By employing a powerful lens, Prochaska found the brain to be composed of a pulp, containing innumerable globules, the ultimate ones being of rather firm consistence, and about eight times less than the red particles of the blood ; and the pulp itself appearing to consist of flocculi, likewise formed of globules, connected by fine cellular substance. By using higher magnifiers, the Wenzels confirmed these observations, and were of opinion that these globules are of cellular texture. More recently, Mr. Bauer confirms the existence of these globules, and observes that they are disposed in lines, so as to give the brain its fibrous appearance, that their diameter varies from $\frac{1}{2400}$ to $\frac{1}{4000}$ of an inch, the general size being $\frac{1}{3200}$, that they are both larger and in greater proportion in the white than in the brown part of the brain, and that they are connected together by a peculiar gelatinous substance.

Thus elementarily constituted, the brain is the

receptacle of the impressions transmitted by the organs of sense ; and, in this view, great importance attaches to Mr. Bauer's having shown that when a portion of recent brain, brown and white, is examined by a high magnifier, the rows of globules pass, without interruption or change of direction, from one part to the other. This corroborates what I formerly stated as to pressure or impression on one end of a series of these globules causing at least projection at the other, and explaining the great velocity of organic action.

In this way, then, may images of external objects evidently be transmitted to the brain. And it is to be well observed that there exists between the organs of sense and the brain, and also between the various parts of the brain, a continuity of structure precisely adapted to a corresponding continuity of transmission.

Thus when a circular impression, as from a ring, or from the transverse section of any cylinder or cone, is made on the tip of the finger or palm of the hand, the nervous globules in a corresponding form must be pressed upward, and the same circle which marks the organ of touch, must be repeated or continued, with a distinctness doubtless depending on the condition of the nervous system, to the very bases of the cerebral convolutions ; for the whole of these ascending parts constitute a single organ.

Thus also, as, from vision, we receive upon the retina accurate impressions of varieties of colour and illumination, and, by their means, of superficial extension and figure, these visible appearances of objects becoming signs of their tangible qualities and distances, it is evident that the image of the largest or most complex nature may be quite as accurately transmitted from the surface of the retina to the brain.

It may be agreeable to those who discredit nature by making her means complex instead of simple, to suppose that the circular impression on the organ of touch in the first of these cases, is not continued to the brain in a corresponding circle, but in a triangle, in the colour blue, in a flash of light, or by any other supposition.

Now it is not difficult to show the fallacy of all such suppositions. — For every distinct external cause adapted to act on each of our organs of sense, we have a distinct internal feeling; the numbers of these external causes and internal effects are therefore apparently equal; and there are no spare ones, none to be thrown away, or to be played with in lusus naturæ — except indeed in monstrous cases. We speak here of what is known to us, not of what is unknown, for that is no affair of philosophy. If then, the forms (or other qualities) involved in internal effects do not accurately resemble those

involved in external causes, there must exist an entire travesty between them — a triangular motion may be the effect of a circular impression, and vice versâ a circular motion may be the effect of a triangular impression. The consequence of this must be that each effect must entirely differ from its own cause, and must perfectly resemble the cause of a quite different effect!

From this monstrous conclusion, contradicted by all the minute and accurate knowledge that we possess of nature, there is no escape, but by supposing that effects resemble their own causes more than they do those of others, that impressions of forms, colours, electricity, &c. are repeated, or rather simply continued, in corresponding motions, that a circular impression for instance is merely continued in a circular motion, and that (as said at the outset of this enquiry) the same circle which marks the organ of touch is formed at the bases of the cerebral convolutions.

But this argument, decisive as it is on the subject, is not the only one. In the minute structure of the nerves, spinal cord and brain — series of globules arranged longitudinally, radiating, or communicating, — we see the actual means of continuing the motions begun in impressions, for, as shown by Mr. Bauer, each globule passes onward and presses onward its

fellow, and we see no means of unnecessarily changing or travestying these motions for different or opposite ones.

Nor is even this all. So far as we can trace nature in these operations, we have positive proof, actual demonstration, that she does merely continue the same forms and actions. Forms accurately corresponding to external scenes are traced on the retina; and vibrations continued from external sounds take place in the ear — for to these its whole structure is adapted.

By such transmitted impressions, then, or I should say by the mere continuance of the same motions through nervous parts which we can prove to be continuous in structure, it no doubt is, that to sensation, which is the function of the organs of sense, succeeds, in the more perfect animals, perception, which is the function of the brain, or more properly of the cerebrum.

Perception requires a common centre, to which impressions may be transmitted. It can, therefore, exist only in man and those animals, which have a common sensorium; whilst zoophytes and vegetables can possess only sensation.

Sensation, then, exists throughout the body, and is independent of perception. Perception, on the contrary, is dependent on sensation. There are organs of sense, as that of touch uni-

versally diffused, without brain: there is no brain, without organs of sense.

Arriving thus at the consideration of perception and the functions of the brain, the vulgar notion on these subjects must now be shown to be founded in ignorance and prejudice, and at utter variance with knowledge, philosophy and truth.

The vulgar notion is, "that, in thought or intellectual processes, there is a physical change in the brain, and also a mental affection, — that these are perfectly distinct from one another, and cannot even be conceived as having the slightest resemblance to each other, — but (as they are inseparable) that they are linked together by some inscrutable bond of connexion."

Now previous to examining this notion and exposing its absurdity (for I shall prove it to be absurd), I must point out the distinction between mind and soul. They cannot, indeed, be confounded; for we see mind or the power of thinking, &c. generated with the body, feeble in infancy, strengthening in youth, vigorous in middle life, decaying in old age, and becoming gradually extinguished in euthanasia senilis, — phases to which an immortal soul cannot possibly be subject. Nothing seems necessary to strengthen this argument.

In the course, however, of the train of reasoning in which I am now engaged, I am led to

another argument on this subject, which completely settles this distinction. Quadrupeds are denied a soul: but, like man, they possess a brain, having every one, or nearly every one, of the parts found in the brain of man. Anatomy proves, as we have already seen, that in proportion as the brain of animals approximates to that of man, their mental functions or powers approximate; and it is therefore to these functions of the brain and its parts which are common to man and animals, and which differ only in their degree of development, that I apply the terms mind, thought, intellect, &c., which, correspondingly, differ in their degree of manifestation.

Of these or other terms, I care not which are allowed me; and though a writer may use any terms with such definitions as are necessary to express his meaning, I am anxious to employ these in the most usual sense. I would, therefore, employ sensation to express the general function of the organs of sense; the Gothic word thought or thinking or the Latin word intellect to express the general function of the brain, consisting of perception, its combinations and the processes to which it is subjected; the words will or volition to express the general function of the cerebel; and the abstract term mind to express the whole.

That animals have *sensation* by means of

their organs of sense, — that they *think*, that is, perceive, compare, remember, &c. by means of their brain, — and that they *will* by means of their cerebel, — in short that, as I employ the term, they possess mind, diminished and modified in conformity with the structure of their nervous system, can be indisputably proved. That they are destitute of soul is agreed. I only, therefore, desire it to be understood, that, *by mind and the terms subordinate to it, I mean the nervous functions common to man and animals, and not soul which is denied to the latter.*

With this clear understanding, one may now examine the notion expressed in the fifth paragraph preceding the present.

The general notion there stated is that, in thought or intellectual processes, there exist "a physical change, a mental affection, and an inscrutable bond." And the writers of this nonsense expect it to be believed that they understand what they write about. They assure us that "the physical change and the mental affection are perfectly distinct from one another," and so well do they know them, that they pronounce — "they cannot even be conceived as having the slightest resemblance to each other." But they do add, that "these things, so perfectly well and familiarly known, are linked together by some inscrutable bond of connexion."

That these assertions involve a gross absurdity is easily shown.—The inscrutable bond of connexion does not of course mean a piece of wood with nails in it, nor a cord of any kind, nor glue or cement: it implies a moral or mental relation. This relation, these writers not only do not know, but they declare that it is unknowable. Now whenever we know the nature of two related objects, and especially when we know them perfectly and in their slightest differences, we inevitably and instantly know their relation to each other; for this relation is only the nature of each, which we already know, viewed in comparison with the other.

Indeed this farrago of words about a physical change, a mental affection, and an inscrutable bond is mere impudent pretence, which the pretender does not clearly understand. In the locomotive system, we have muscular motion; but we do not add to it a motive affection and an inscrutable bond. In the vital system, we have circulation; but we do not add to it a circulating affection and another inscrutable bond. It is equally unwarrantable to do so in the mental system, where the terms employed imply merely the actions or functions of those organs which man possesses in common with inferior animals, and not the soul of which these animals are destitute.

If, in short, perception and its consequences

were not the functions of the brain, it would have no function at all.

Now we know, that functions are the motions of peculiar structures, and therefore, even the most secret of all functions must consist of a series of motions, the infallible property of which is, from a cause, to produce effects, by bringing bodies either into connexion by media or into actual contact.

Moreover, as sensation and perception are implicitly dependent upon motion, and as the latter, and all the functions of the brain, are mere combinations of perception or processes to which it is subjected, they also must be dependent on motion. And this is confirmed by the white substance of the brain throughout consisting of similar series of globules arranged longitudinally, radiating, or communicating in various directions, obviously for the purpose of communicating motion like the nerves, and, by the change of arrangement or connexion, causing a corresponding change of cerebral action and consequently of mental operation.

Finally, it has also been seen that appropriate means of transmitting motions may be said actually to *constitute* the nervous system.

The existence indeed of ideas (their literal meaning being forms, shapes, appearances, images) in consequence of nervous motion, is certainly not, upon this principle, nearly so wonderful as

the electricity which the gymnotus, silurus, or torpedo, produces by means of its nerves—a circumstance, however, which maintains a remarkable analogy between electricity and its conductors, and sensibility and its conductors, the nerves, and which at the same time, shows, that all these affairs consist of physical motion. —In Thompson's Annals of Philosophy for 1815, I have shown that electricity consists in the motions accompanying the decomposition and recomposition of atmospheric air; and that galvanism consists in the motions accompanying the decomposition and recomposition of water; the sole materials of the former being oxygen and azote, and those of the latter oxygen and hydrogen. Hence electricity and galvanism accompany all the vital phenomena in which such changes take place.

Indeed every advance which we make in the knowledge of nature proves to us, that her operations are always simpler than we are apt to suppose, and that we always miss their causes by stepping over them, and looking for them beyond the point at which they lie, and that always in some complexity and confusion produced either by ourselves or others.

The argument, therefore, which Mr. Hume, in support of his peculiar doctrine, borrows from anatomy, namely, that the power by which muscular motion is performed is mysterious and

unintelligible, and that effects of which we are ignorant and in themselves totally different from those intended, are first produced—this argument, I should say this mere assertion, is now shown to be inaccurate, because, as the preceding reasonings prove, the effect produced differs from that intended, only in as much as the termination of a continuous motion differs from its commencement. The beautiful perpetuation of the same species of motion throughout the tubular organs of the vital system, is at once an excellent illustration, and an analogical proof of similarly continued motion throughout the intellectual system.

The same argument applied by Mr. Hume to prove, that we are conscious of no power in the mind, when, by an act or command of the will, we raise up a new idea, fix the mind to the contemplation of it, turn it on all sides, and, at last, dismiss it for some other idea, when we think that we have surveyed it with sufficient accuracy, is equally refuted by the same observation, and must appear strikingly inaccurate, when in addition to this, it is observed, that all his terms 'act or command of the will,' 'raise up an idea,' 'fix the mind,' 'turn the idea on all sides,' 'dismiss the idea,' express nothing but motion and consequently power, and therefore refute his assertion.

The use, indeed, of active verbs, and the lan-

guage in general used in expressing natural operations, by the universal consent which they exhibit, become proofs of the existence of motion in them. It may be said, that we are obliged to use these terms merely because our language affords no other. But it is a fact, that no language affords any other, nor does it appear possible to form any other. In such instances as the above, power is as much demonstrated as if external motion had been produced; an internal movement evidently takes place, and a train of ideas is carried on.

As all language, therefore, relative to the mind, expresses motion, and as we cannot even have an idea of its operations, or of any operation, without motion, any denial of this must, consequently, have its foundation, since not in reason, certainly in prejudice.

Mr. Locke, accordingly, in his work on the human understanding, says, "As to the manner in which bodies produce ideas in us; it is manifestly by impulse, the only way which we can conceive bodies to operate in;" and notwithstanding the false assertion that he retracted this, it retains its place in that work.

Cerebral and muscular motion even alternate with each other in such a manner as to prove their continuity or identity. Dr. Darwin, in his Zoonomia, says, "In some convulsive diseases, a delirium or insanity supervenes, and the con-

vulsions cease; and conversely the convulsions shall supervene, and the delirium cease. Of this I have been a witness many times in a day in the paroxysms of violent epilepsies; which evinces that one kind of delirium is a convulsion of the organs of sense, and that our ideas are the *motions* of these organs."

Hence it is that a general compression of the brain, by preventing its natural motions, instantly destroys sensation.

Every view, then, proves that the functions of the brain, or the intellectual functions, are the motions of its parts. Thus evident motion takes place in impression; a less evident, but still acknowledged one, in intellectual operation; and again, an evident one in the acts of volition. But motion not only demonstrates itself in impression; seems continued in thinking; and again, evidences itself in expression; but beautifully corresponding to the general laws of the most evident species of motion, it does not terminate here without communicating new and similar motions—another series of impressions, ideas, emotions, passions and volitions, to other minds.

If it be still found difficult to conceive how matter and motion can produce these wonderful effects, I need only at present observe, that the combination of matter in its grossest forms, viz. the mixture of the seminal and ovarian liquids, actually produces the organs of sense, brain and

nerves—the intellectual organs of the whole race of animals; and that as the actions of all bodies depend upon their structure, consequently the actions or the functions of these parts have one and the same origin.

The mere projection of the last globules of the nerves of impression or sensation into the convolutions and ventricles of the brain, and the impulsion of those of volition or expression, may account for all the phenomena

For the purpose of throwing another kind of difficulty in the way of rational inquiry, it has been contended that the intellectual operations have continued unimpaired in persons whose brain has been altered by disease or removed in accidents. But the cases of this kind are always reported by men incapable either of observing minute structure or mental function, and are always placed by time, locality or circumstances beyond the reach of accurate observers. They are in fact stupid mistakes, or impudent fabrications.

These the Wenzels have noticed as follows: "It has been said that sometimes in fracture of the cranium a considerable portion of the brain has been removed without any consequent detriment to the patient. Such observations, if at all conformable to truth, would afford the argument that a great part of the brain is evidently useless and superfluous. We believe, however,

that such observations have not hitherto been instituted with sufficient care and accuracy, and that patients of this kind have not been observed so unintermittingly and exactly, in a psychological respect, that from them the conclusion can be drawn that a considerable portion of the brain, an organ of such vast importance in man, is useless and superfluous, and the objection which for that reason may be brought against assertions of this kind is evidently confirmed and placed beyond a doubt."*

With regard to the uses of the cerebral parts, Mr. Mayo, however, in his Physiology, says, "We may next inquire, whether an increasing number and complication in the parts of the brain is essentially connected with improved mental functions.—The instantia crucis, how-

* Observatum fertur, in fractura cranii quandoque non modicam cerebri portionem, absque aegrotantis detrimento inde secuto, demtam fuisse. Quae observationes si omnino veritati consentaneae essent, argumento forent, magnam cerebri partem plane inutilem esse atque supervacuam. . . . Credimus autem observationes illas usque huc non rite accurateque satis fuisse institutas et aegrotantes ejusmodi homines non tam continenter et exacte respectu psychologico observatos esse, ut ex his conclusio, non modicam videlicet partem cerebri, quod tam magni in homine momenti organon est, inutilem ac supervacuam esse, et illa, quae inde contra hucusque dicta formari posset, objectio plane firmari atque omnem extra dubitationem poni possit. —*De Penitiori Cerebri Structura, p.* 257.

ever, upon this question, is found in the comparison of the brain of the cetaceous mammalia with the human brain on the one hand, and with that of fish on the opposite.—The cetaceous mammalia have brains which, besides being of large size, are nearly as complicated as those of human beings; they might therefore be expected, if the opinion which I am combating were true, to manifest a remarkable and distinguishing degree of sagacity. Endowed with a brain approaching nearly in complexity and relative size to that of man, the dolphin should resemble in his habits one of the transformed personages in eastern fable, who continued to betray under a brute disguise their human endowments. Something there should be very marked in his deportment which should stamp his essential diversity from the fishes, in whose general mould he is cast. His habits too, not shunning human society, render him especially open to observation; and the class of men who have the constant opportunity of watching his gambols in the deep are famed for their credulity, and delight to believe in the mermaid, the sea-snake, and the craken. Yet the mariner sees nothing in the porpesse or the dolphin but a fish, nor distinguishes him except by his unwieldy bulk, from the shoal of herrings he pursues. The dolphin shows, in truth, no sagacity or instinct above the carp, or the trout, or the sal-

mon. It is probable even that the latter, which have but the poorest rudiment of a brain, greatly exceed him in cunning and sagacity.—I am afraid that the instance which I have last adduced, is sufficient to overthrow most of the received opinions respecting the relation of the size and shape and organization of the brain to mental development; nor is it easy to find a resting place for conjecture upon this subject."

It is certainly a novelty in science that the testimony of men famed for their credulity and who delight to believe in nonsense, should be thought a good means of deciding a question like this. Credulous men are never observers, precisely because they are credulous. From Mr. Mayo's way of speaking, one would imagine that Arsaky, Klein, Rosenthal, Schneider, or some of those who have made most observations on fishes, should have been sailors or fishermen; whereas it may perhaps be questioned if any one such person ever made a single observation on the animals which are most exposed to his notice. When, indeed, we consider the multitude of animals which, for thousands of years, even naturalists have had under their eyes, and of whose habits they know little or nothing, can we wonder that ignorant and credulous men should know as little of animals of which they get but an occasional glimpse. Mr. Mayo's conclusion, therefore, that the dolphin shows

no sagacity, founded apparently on such evidence, is good for nothing. The single circumstance of this animal suckling its young, the continued attachment which this implies, the observation, the care, the providence which this requires, are proofs of a sagacity far above that of true fishes. Captain Scoresby, accordingly, says that the whale, when its young is harpooned, evinces "a degree of affectionate regard for its offspring that would do honour to the superior intelligence of human beings." His work affords decisive proofs of the great intelligence of these animals.

But Mr. Mayo adds "The brains of monkeys have a strong general resemblance to the human brain. This must surely refer to the resemblance of their physical organs to those of man, not to their sagacity: the dog should else have a brain shaped like that of the monkey."

The sagacity of the monkey has always been a subject of admiration. Among the Arrowacks of South America, Dr. Hancock informs me, the Quata takes care of the house, carries water for the family, and does other domestic duties. That the monkey's sagacity is no greater, is very well explained by Soemmerring's observation as to the orang-utang: "that the small brain of that animal declares the physical and precise cause why it is so far behind man in the faculties of the mind. For the greatest part of

the organ being deficient, it is necessary that the actions of the organ should be deficient also."*—As to the dog, he does not approximate to the monkey in intellect. The former, in common with very inferior animals, has passive and limited docility: the latter has nearly the highest degree of active ingenuity.

In the *same* work, however, these things appear to be compensated for by Mr. Mayo by a very *opposite* statement. "Wherever our knowledge of any branch of natural philosophy is sufficient to enable us to study with success the uses of a part of the animal frame, we *invariably* discover the most exact adaptation of the physical structure to the office of the part. . . It is impossible for us therefore to doubt, that in the brain there is the same exquisite fitness to the purposes for which it is designed. . . The composition of the brain is doubtless as exactly suited to the phenomena of thought and feeling, as the structure of the eye to the properties of light."

I might here close my observations on the general function of the brain; but, previous to proceeding to the functions of particular parts, it is necessary even to clear away the rubbish

* Parvus ergo encephalus orang-utangi rationem physicam et certam prodit, cur animi facultatibus tantopere ab homine distet. Deficiente enim maxima parte organi, actiones ejusdem organi etiam deficiant necesse est.—*Tabula Baseos Encephali*, p. 9.

which sometimes embarrasses this one. I think it expedient, therefore, to make a brief dissection of the most systematic attack upon the interests of truth as to the cerebral functions which I can find. And here the difficulty really is to find any of these at all respectable in point of argument. They are generally written by sciolists who unhappily mistake their zeal for ability; and sometimes, by persons who have specific motives for writing. As, however, a work on physiology, otherwise amusing to common readers, by Dr. Roget, contains a concentration of all the most erroneous arguments of this description, and as it is the most recent one of the kind, I shall briefly dispose of each of these as it presents itself in his chapter on perception.

"Although," says Dr. Roget, "the corporeal or physical change taking place in the sensorium, and the mental affection we term sensation, are linked together by some inscrutable bond of connexion, they are, in their nature, as perfectly distinct as the subjects in which they occur; that is, as mind is distinct from matter; and they cannot, therefore, be conceived by us as having the slightest resemblance the one to the other."

This is the assertion which has just been shown to be a tissue of nonsense, and to involve a gross absurdity. The notion that there exist physical changes, mental affections, and

an inscrutable bond, instead of functions performed by the brain and corresponding to those performed by the other organs, — this making of mental operations or the actions of the brain, distinct existences, and personifying them under the general name of mind, *the* mind, is the cause of all the errors I have now to expose, and the grossness of which will be readily acknowledged.

Dr. Roget nearly approaches the truth when he says that "sensations invariably suggest to the mind ideas, not only of the existence of an external agent as producing them, but also of various qualities and attributes belonging to these agents;" — that "it is certain, from innumerable facts, that in the present state of our existence, the operations of the mind are conducted by the instrumentality of our bodily organs;" — and that "the brain is the material instrument by which we retrace and combine ideas, and by which we remember, we reason, we invent."

Now here the brain is distinctly allowed to be the instrument of mental operations, the instrument by which we remember, reason and invent; and yet the same writer asserts that *the operations of this instrument are not its own operations!* that they are the operations of something else! the operations of an abstract term!

"In experiencing mere sensations," says Dr. Roget, "whatever be their assemblage or

order of succession, the mind is wholly passive: on the other hand, the mind is active on all occasions when we combine into one idea sensations of different kinds (such as those which are derived from each separate sense), when we compare sensations or ideas with one another, when we analyze a compound idea, and unite its elements in an order or mode of combination different from that in which they were originally presented."

True; and this activity is a voluntary activity, the consequence of a reaction of the cerebel upon the brain, which, as I shall afterward show, is duly provided for in their organization; but then will or volition is no new and lawless interference of a foreign power, but the *necessary* consequence of preceding cerebral action and its various combinations.

"Many of these active operations of mind," says Dr. Roget, "are implied in the process of perception; for although it might be supposed that the diversity in the nature of our sensations would sufficiently indicate to us a *corresponding* variety in the qualities of the material agents, which produce their impressions on our senses, yet these very qualities, nay, even the existence of the objects themselves, are merely inferences deduced by our reasoning powers, and not the immediate effects of those impressions on the mind."

These inferences are not those of any independent power, nor are they such as we could possibly avoid: the doing so would constitute insanity. Such inference is a mere propagation of the ideas or images of such material agents, and even when it leads to complicated processes, it is only modified by past impressions, present wants, &c. The abstract term mind is therefore no more independent or creative than any other abstract term.

"We talk, for instance," says Dr. Roget, "of seeing a distant body; yet the immediate object of our perception can only be the light, which has produced that particular impression on our retina; whence we infer, by a mental process, the existence, the position, and the magnitude of that body."

The eye, which has to do with light, is nevertheless a favourite subject with the spreaders of darkness. We derive not from it, however, the perception of mere light, but of colours and figures which are distinctly traced upon the retina, and which of course are, in the same homogeneously constituted nervous matter, continued to the brain. Light, colours, shapes may thus be said to touch the brain as truly as they touch the eye; and the operation can be called an inference only in the Latin sense of something brought in. But the attraction of the eye to arguers of this kind is that, by its

means, we do make real inferences as to position and magnitude, and they expect these to be confounded with the rest. These, however, are not direct objects of the sense of sight; and we know them by means of it, only as we know the objects of any one sense by means of another. They afford, therefore, no proof of inferences made as to the proper objects of sight.

"When we hear a distant sound, the immediate object of our perception is neither the sounding body whence it emanates, nor the successive undulations of the medium conveying the effect to our ear; but it is the peculiar impression made by the vibrating particles of the fluid, which are in direct contact with the auditory nerve."

No one, I believe, ever thought of perceiving a sounding body by means of its sound; but we may be said to perceive its vibrations and those of the atmospheric medium, as well as those in the ear and brain, in so far as they are one and the same series of motions, little, if at all, changed by the media transmitting them, else could we not distinguish the quality, timbre, gepräge of sound produced by each different body. The physiology of the ear illustrates, in the clearest manner, the identity of the external and internal motions.

"It is not difficult to prove that the objects of perception are mere creations of the mind,

suggested, probably instinctively, by the accompanying sensations, but having no real resemblance or correspondence either with the impressions themselves, or with the agencies which produce them."

Having already destroyed the Doctor's premises as to mental inferences, which he now, exactly like a magician or harlequin, changes into creations made by instinct, his conclusion deserves little notice. No mind ever created any thing in any rational sense of the word. But I proceed to his proofs that the objects of perception have no real resemblance or correspondence either with the impressions themselves or with the agencies which produce them.

"Many," he asserts, "are the instances in which our actual perceptions are widely different from the truth, and have no external prototype in nature."

I am willing to meet in succession the strongest proofs he can offer of this.

"In the absence of light, any mechanical pressure, suddenly applied to the eye, excites, by its effect on the retina, the sensation of vivid light. That this sensation is present in the mind we are certain, because we are conscious of its existence: here there can be no fallacy. But the perception of light, as a cause of this sensation, being inseparably associated with

such sensation, and wholly dependent on it, and corresponding in all respects, both as to its duration and intensity, with the same circumstances in the sensation, we cannot avoid having the *perception* as well as the *sensation* of light: yet it is certain that no light has acted. The error, then, attaches to the perception; and its source is to be traced to the mental process by which perception is derived from sensation."

If ever there was a beautiful illustration of the figure which Byron calls rigmarole, this certainly is one. Here pressure excites what the writer calls a sensation of light; this sensation is in the mind; a perception is dependent on it, and corresponds with it in all respects as to duration and intensity, so that we cannot avoid having both perception and sensation; but as no light has acted, the error attaches to the perception and not to the sensation, which equally exists in the mind, and to which the perception corresponds! As has been already shown, sensation takes place in organs of sense; and perception is only another name for it on reaching the common sensorium. There can, therefore, be no error, nor even discrepancy between them. In this case, however, there is merely a perception of something like prismatic colours; and as colours depend on the relative position of the particles of bodies, this appears to be produced, in the derangement of those of

the retina, by pressing its concave into a convex surface at a particular point, or by pressing the intermediate humours against the opposite side. Here therefore there is no proof that the perception does not perfectly correspond with the impression producing it.

The same observations apply to the doctor's "appearance of a flash of light from the transmission of the galvanic influence through the facial nerves."

"A similar fallacy," he tells us, "occurs in the perception of taste, which arises in the well-known experiment of placing a piece of zinc and another of silver, the one on the upper and the other on the under surface of the tongue, and making them communicate, when a pungent and disagreeable metallic taste is instantly perceived: this happens because the nerves of the tongue, being acted upon by the galvanism thus excited, communicate the same sensation as that which would be occasioned by the actual application of sapid bodies to that organ."

If the taste here experienced had been a vegetable or an animal one, there might have been some reason for suspecting magic or harlequinade; but as it is only that of the metal which the man actually holds in his mouth, the matter is plain enough. In all galvanic operations, there is a decomposition of water, and this appears to facilitate the detachment of those me-

tallic particles which cause peculiar taste, and which in the instances of iron, copper, &c., produce that effect without galvanic aid. It in no way, therefore, appears, as asserted by the doctor, "that causes which are very different in their nature, may, by acting on the same nerves, produce the very same sensation;" nor does it follow, "that our sensations cannot be depended upon as being always exactly correspondent with the qualities of the external agent which excites them." On the contrary, in all these cases, the perception perfectly corresponds with the impression producing it.

"Evidence to the same effect," says Dr. Roget, "may also be gathered from the consideration of the narrowness of those limits within which all our senses are restricted. It requires a certain intensity in the agent, whether it be light, or sound, or chemical substances applied to the senses of smell or taste, in order to produce the very lowest degree of sensation."

It requires a certain intensity in the agent, that is some action. Because a high degree of sensation is produced by great intensity, would the doctor have the lowest degree of sensation produced by no intensity at all? If it is here meant that there are degrees of action yet less than the least which we can distinguish, this does not impugn the accuracy or truth of what we do distinguish.

"On the other hand, when their intensity exceeds a certain limit, the nature of the sensation changes, and becomes one of pain."

That is, when the impression on an organ destroys its organization, or impedes its function. The effect is a very natural and proper one; and it is difficult to see what else the doctor would have.

"Of the sensations commonly referred to the sense of touch, there are many which convey no perception of the cause producing them. Thus a slighter impression than that which gives the feeling of resistance produces the sensation of itching, which is totally different in its kind."

A substance may slightly impress the organ of touch, and by motion upon it may produce the irritation called itching; but why should it give us a sensation of form (for this is the proper object of touch) when no form has been impressed upon the organ. This is only another proof that perceptions correspond with impressions.

"The sensation of cold is equally positive with that of warmth, and differs from it, not in degree merely, but in species; although we know that it is only in its degree that the internal cause of each of these sensations differs."

Here two different things are confounded—temperature generally considered which differs only in its degree, and the effects of tempera-

ture upon the human body. The latter has a temperature of its own, and having also a sense of heat, it of course distinguishes, and truly distinguishes, whatever is above it, as positively the opposite of whatever is below it; and heat and cold in common language mean no more than these opposite relations of temperature.

"The only distinct notions we are capable of forming respecting *matter*, are that it consists of certain powers of attraction and repulsion, occupying certain portions of space, and capable of moving in space; and that its parts thereby assume different relative positions or configurations. But of *mind*, our knowledge is more extensive and more precise, because we are conscious of its existence, and of many of its operations, which are comprised in the general term *thought*."

If the hypotheses of attraction and repulsion were, as here implied, the bases of all our knowledge of matter, it would be very slender; but we possess respecting it and its properties, much accurate knowledge. Respecting mind, on the contrary, if the extent and preciseness of our knowledge is to be judged of from the paragraphs of the writer who here lays claim to them, they would, if there be aught of truth in these strictures, be small indeed.

"To assert that thought can be a property of matter, is to extend the meaning of the term

matter to that with which we cannot perceive it has any relation."

Neither external motion nor internal thought may rightly be called properties of matter; but all we have already said—I should say every thing we know of mental physiology, proves that they have the most intimate and the strictest relations.

"All that we know of matter has regard to space: nothing that we know of the properties and affections of mind has any relation whatsoever to space."

Precisely the reverse is true. Mental operations are internal motions, and could not exist independently of space. Moreover, it is by means of the mind alone that all our relations to space and the objects it contains, are maintained.

"A similar incongruity is contained in the proposition that thought is a *function* of the brain. It is not the brain which thinks, any more than it is the eye which sees, though each of these material organs is necessary for the production of these respective effects. That which sees and which thinks is exclusively the mind; although it is by the instrumentality of its bodily organs that these changes take place."

If the organs of sense do not perform the functions of sensation as their name implies, they perform no function at all. But we know

that, with every improvement in their organization, the function of sensation improves, and *that* even though the brain degenerate in magnitude and number of parts. We find the eye proportionally larger and vision more acute, while the brain is less, in some of those quadrupeds which accordingly have least mind. This acuteness of vision is more remarkable in birds, which have a still smaller brain; and it is supposed to be still more remarkable in insects, which have little or no brain at all. Is it, then, mind which sees, in a greyhound, or a hawk, or a bluebottle! It is really amazing into what nonsense men are led by prejudice.

A concession is made here by Dr. Roget, whence two important conclusions may be derived.—1. *As, according to him, it is not the eye but the mind which sees, it follows that every thing which sees has mind.*—2. *As it is not every thing which sees, but man alone, who has an immortal soul, it follows that mind and soul are utterly different.*—So far, therefore, as goes the conscientious, however unenlightened, support of the secretary of the Royal Society, the fundamental distinction which I laid down between mind and soul is here corroborated by him in the clearest and strongest terms. It is not, indeed, for the intrinsic worth of this support, that I quote it; but merely as showing that the distinction is in no way hostile to religion, which

ignorant and interested persons are apt to allege in such cases.

But I had almost forgotten the other assertion in the doctor's paragraph, that it is not the mind which thinks. All that goes before, and all that follows, prove the reverse. And, as the doctor asserts soul and mind to be distinct, it is difficult to imagine why he so vainly struggles to make mind independent of structure. Is the doctor of opinion that independence of structure is so good a thing that he cannot have too much of it?

"The sensations derived from the different senses have no resemblance to one another, and have, indeed, no property in common, except that they are felt by the same percipient being. A colour has no sort of resemblance to a sound; nor have either of these any similarity to an odour, or a taste, or to the sensations of heat, or cold. But the mind, which receives incongruous elements, has the power of giving them, as it were, cohesion, of comparing them with one another, of uniting them into combinations, and of forming them into ideas of external objects. All that nature presents is an infinite number of particles, scattered in different parts of space; but out of these the mind forms individual groups, to which she gives a unity of her own creation."

By the want of resemblance between the

qualities of matter, mentioned in the first and second sentences, Dr. Roget means incongruity as stated in the beginning of the third. Now that the elements or qualities of matter are incongruous, as there asserted, is so obviously absurd as to be unworthy of notice. If colour depend on the arrangement or relative position of particles, and sound on the motions of these particles, and smell and taste on similar qualities in relation to nutrition, they are not only not incongruous, but so intimately related, so much the same, that it seems to require an absolute analysis by means of organs of sense in order to distinguish them. As to the assertion in the last sentence, that nature presents only an infinite number of particles, scattered in different parts of space, and also that the mind unites these particles into groups of her own creation, the whole, I should imagine, from this female personification of mind, is meant as a poetical flight—it has no relation to truth.

"The picture formed on the retina by the refracting power of the humours of the eye, is the source of all the perceptions which belong to the sense of vision: but the visible appearances which these pictures immediately suggest, when taken by themselves, could have given us no notion of the situation, distances, or magnitudes of the objects they represent; and it is altogether from the experience acquired by the exercise of other senses that we learn the relation which

these appearances have with those objects. In process of time, the former became the signs and symbols of the latter; while abstractedly, and without such reference, they have no meaning. The knowledge of these relations is acquired by a process exactly analogous to that by which we learn a new language."

Again we have the organ of light made use of for the purpose of darkness. The picture on the retina could of itself give no information of distance and magnitude, because it is not those but colours which are its objects. Its direct information therefore, as to the latter, must not be confounded with its inferential information as to the former, as the lovers of obscurity desire. The assertion, however, that the appearances whence we infer distance and magnitude, have no more natural connexion with these than the words of a new language have with those of an old one, or that the relations in both cases are acquired by an exactly analogous process, is here made for the purpose of inducing the reader to suppose that there is only a vague connection between them. This is not true: the analogy is false. The inferences which, from visible appearances, we make as to distance and magnitude, are natural, and similar under similar physical and mental circumstances: the relations which the words of one language bear to those of another are altogether arbitrary and accidental.

"On hearing a certain sound in constant con-

junction with a certain idea, the two become inseparably associated together in our minds; so that on hearing the name, the corresponding idea immediately presents itself. In like manner, the visible appearance of an object is the sign, which instantly impresses us with ideas of the presence, distance, situation, form, and dimensions of the body that gave rise to it."

Here the application of an analogy which was false even in regard to distance and magnitude, because our inferences respecting them are natural and similar under similar circumstances, is perverted by Dr. Roget, as was evidently his intention, to presence, form and dimensions. Now, as to presence and that degree of form and dimension called figure, shape or outline, we draw no inference at all—unless, as already said, in the original sense of something brought in. It is therefore not true that "this association is, in man at least, not original, but acquired."

"The objects of sight and touch, as Bishop Berkeley has justly observed, constitute two worlds which although they have a very important correspondence and connexion, yet bear no sort of resemblance to one another."

Bishop Berkeley, had much of that skill, which Dr. Roget in vain tries to put forth, of making nonsense appear like sense, and is therefore very properly appealed to in this case; but neither his authority nor his follower's admira-

tion of the justice of his observation will have any weight with those who can reason for themselves. And they will have the less weight because, in this case, his follower knows nought of his ingenious and really beautiful consistency; for the doctor has no sooner asserted that the tangible and visible worlds bear no sort of resemblance to one another, than, to show as it were what nonsense the defenders of false principles and spreaders of darkness must utter, he flatly contradicts himself by adding that "The tangible world has three dimensions, namely, length, breadth, and thickness; the visible world only two, namely, length and breadth"—which is to say, that there is two thirds of perfect resemblance, and only one-third of difference, between them.

"The objects of sight constitute a kind of language, which nature addresses to our eyes, and by which she conveys information most important to our welfare. As, in any language, the words or sounds bear no resemblance to the things they denote, so in this particular language the visible objects bear no sort of resemblance to the tangible objects they represent."

The doctor absolutely luxuriates and revels in self-contradiction. In the last sentence, he granted two-thirds of perfect resemblance between visible and tangible objects; and he now says there is none! and re-asserts what I have

now repeatedly shown to be false in whatever way it is viewed.

"The theory of Berkeley received complete confirmation by the circumstances attending the well known case, described by Cheselden, of a boy, who, from being blind from birth, suddenly acquired, at the age of twelve, the power of seeing, by the removal of a cataract. He at first imagined that all the objects he saw touched his eyes, as what he felt did his skin; and he was unable either to estimate distances by the sight alone, or even to distinguish one object from another, until he had compared the visual with what has been called the tactual impression."

As to distances and magnitudes, it was not to be expected he could estimate them, because, as has been repeatedly observed, they are not, by a direct process, objects of sight. But it is the conclusion of the paragraph, perhaps, that brings the very cheval de bataille of this complete confirmation—"he was unable to distinguish one object from another, until he had compared the visual with the tactual impression." Now, even with the long continued and full possession of his senses, no human being ever distinguished any two objects until he had compared them! And that a man should at first seek assistance from an old and vigorous sense in behalf of a new and feeble one, by which he must have been rather dazzled and confounded

than instructed, would have been perfectly natural, even if there had been more than two-thirds of perfect resemblance between their objects, as the doctor so queerly asserts and denies.

"This theory also affords a satisfactory solution of a question which has frequently been supposed to involve considerable difficulty, namely, how it happens that we see objects in their true situation, when their images on the retina, by which we see them, are inverted."

The doctor's solution is that "It is not the eye which sees, it is the mind."—Similarly, as already observed, it is not the eye of a brainless insect which sees; it is the insect's mind! And as, in man, it is not the surface of his skin and of his fingers in particular which feels, but his mind: so it is not the general surface of the polyp destitute equally of brain and nerves, which feels, it is the polyp's mind!

"Far from there being any contemplation by the mind of the image on the retina, we are utterly unconscious that such an image exists, and still less can we be sensible of the position of the image with respect to the object."

We are unconscious of the image or its inversion, because consciousness belongs not to sensation but to perception which takes place only in the brain.—But here a remarkable fact presents itself. *An image, and that image inverted, exists in the eye.* The doctor will not deny

that it is there for a necessary and important purpose. That purpose, however, is not our consciousness of it. As he observes, we are unconscious either of it or its position in the retina. It marks the organ, however; and *it is therefore organically, physically, necessary.* This shows that *the forms of external objects are necessarily maintained or propagated through the nervous system, whether we are conscious of them or not.*

"All that we can distinguish as to the locality of the visual appearance which an object produces, is that this appearance occupies a certain place in the field of vision; and we are taught, by the experience of our other senses, that this is a sign of the existence of the external object in a particular direction with reference to our own body."

The doctor misrepresents every thing he touches. All, he says, that we can distinguish is that it occupies a place. But as this place has an outline, we thereby distinguish its shape, which is its form in length and breadth, though not in thickness; and this is vastly more than being a mere "sign of the existence of the external object in a particular direction with reference to our own body."

After something more of this kind Dr. Roget adds, "Many other examples might be given of similar fallacies in our visual perceptions."

I will only add, that, if they resembled the

preceding, there would be found to be involved in their statement errors as egregious, or in their conclusions falsehoods as palpable, as those I have just exposed.

How admirably suited to Dr. Roget's taste, would be the Irish lecturer (not the profound thinker who is now professor at Trinity College), who saw in the brain such a useless mass of confusion, that, *for his own part,* he thought a quart of stir-about would do instead of it! The physiologists of this school are still very numerous.

Having thus established, both by general reasoning and by a critical examination of the arguments opposed to it, the truth that the mental operations are the functions of the brain, I proceed now to consider the succession of these in its anterior, middle, and posterior parts, but still in a general way.

It is of great importance, in relation to the doctrine of the mental functions which is delivered in this work, and which is the only object of its anatomical details, to remark, that the developement of these hemispheres is always from before backwards—precisely in the direction which I have assigned to the functions generally.

This, as corresponding with the early formation in the fœtus of all the anterior parts, already described, while an open canal exists in place of the posterior ones, at a time too (before the fourth month) when, in consequence of the

latter circumstance, locomotion cannot be performed, — this development, I say, being always from before backward, strongly supports the general doctrine here delivered.

Tiedemann, accordingly, observes that the hemispheres, in the fœtus as well as in animals, are developed laterally and from before backward; that they extend in the latter of these directions, successively over the anterior striated bodies, posterior striated bodies, tubercles, and at length over the cerebel; and that these portions of the brain become gradually more elevated and more convex, &c.*

It follows that the direction of cerebral action or function corresponds with the direction of cerebral growth and organization; for wherever there is structure there is function. The direction of cerebral function is therefore from before backward.

This fact admirably supports the view I have already given of the ascending actions of the anterior nerves, columns and radiating masses, and equally supports the view I have to give of the backward actions of the intermediate parts,

* Aus allem dem erhellet, dass die Bildung der Hemisphären des grossen Hirns im Fötus wie in den Thieren von vorn und von den Seiten ausgeht, und dass sie sich successive von vorn nach hinten über die gestreiften Körper, die vermeintlichen Sehnervenhügel, die Vierhügel und endlich auch über das kleine Hirn ausbreiten. Ferner, dass die Hemisphären allmählig höher und gewölbter werden.—*Anatomie und Bildungsgeschichte des Gehirns, p.* 147.

and of the descending actions of the posterior columns, nerves, &c. because it contributes to establish the communication between the former and the latter.

It is natural to enquire whether, in this successive growth of cerebral parts, and extension of mental function, from before backward, the three lobes of which each hemisphere consists are to be found together at the anterior part of the mass, only reduced in size even from the first, or whether it is the anterior lobes which first appear, and the middle and posterior which succeed them. The first case would imply the coexistence, in however feeble a degree, of all the functions these parts may exercise: the second would imply that the function of one preceded that of another.

Tiedemann informs us that, toward the end of the third month, each hemisphere consists only of an anterior lobe, for the middle and posterior form but a small rounded appendage;* that, in the fourth month, laterally and beneath, we find each hemisphere divided by a groove (the fissure of Sylvius), into an anterior large lobe, and into another small mass corresponding both to the middle and posterior lobes;† that, in the

* Jede Hemisphäre besteht nur aus dem vorderen Hirn-Lappen, denn der mittlere und hintere Lappen stellen nur einen kleinen abgerundeten Anhang dar.—*Ibid. p.* 141.

† Von der Seite und von unten angesehen ist jede Hemisphäre durch eine schwache Vertiefung, die sylvische

sixth month, underneath we observe the anterior, middle and posterior lobes,* the middle, which form a round prominence, being separated from the posterior by a slight depression;† and that, in the eighth month, on examining their inferior surface, we perceive the anterior, middle and posterior lobes, the respective limits of which are well defined.‡ We, moreover, know that no animals below the quadrumana at any period possess posterior lobes.§

Hence, then, it follows that the direction of cerebral function is not only from before backward, but that the functions of the anterior lobes, separately and distinctly, precede those of the middle and of the posterior—the latter never at all existing in quadrupeds.

That the functions of the lobes are more or less distinct is proved by the corresponding distinction of parts; for nature does nothing in

Grube, in den grossen vorderen, und in den kleinen gemeinschaftlichen mittleren und hinteren Lappen abgetheilt.—*Ibid. p.* 141.

* Die Hemisphären von unten angesehen, zeigen die vorderen, die mittleren und die hinteren Lappen.—*Ibid. p.* 142.

† Die mittleren, abgerundet vorspringenden Lappen sind durch eine Einsenkung von den hinteren Lappen geschieden.—*Ibid. p.* 142.

‡ Man erblickt an der unteren Fläche die deutlich abgegränzten vorderen, mittleren und hinteren Lappen.—*Ib. p.* 142.

§ Allen Thieren, auch selbst den Säugethieren, mit Ausnahme der Affen, der hintere Lappen des grossen Hirns und das hintere Horn des Seitenventrikels fehlt.—*Ibid. p.* 172.

vain, and a distinction of organ is a distinction of action.

Now the distinct functions of these superior parts of the brain is a subject of immense importance, because it is in them that all the ascending fibres end, and all the returning fibres begin, because on them probably impressions are made and maintained, because from being superficial they afford some means of physiognomical observation, because they are more exposed to injuries, and because, with some notion of their functions, we may better observe the effects of the loss of particular portions of their superior parts.

The subject presents peculiar difficulties owing to the degree of resemblance between the parts; but still some guidance is afforded us by their evolution being successive, and by the distinction subsisting between them from the first.

As, then, in the mass of the hemispheres constituting nearly the whole of the brain, there is nothing so remarkable as their distinction into three lobes, so with regard to the functions which the brain performs, the chief and indeed the usual distinction of mental results is into ideas, emotions and passions, of which the craniological arrangement — propensities, sentiments and intellectual qualities, is only a disordering and injurious inversion.

In these mental results, ideas precede, be

cause they are the mere consequence of our combining perceptions; emotions, in which pleasure or pain is superadded to ideas, follow, because they flow from the next operation of comparing; and passions, in which desire or aversion is superadded to emotions, succeed, because they spring from the yet more advanced act of determining.

Thus, these three great acts of the brain succeed in the same order with its three principal parts; and we might thence be induced to suspect that the anterior lobes had some connexion with ideas; the middle, with emotions; and the posterior with passions.

Respecting such relations as these between parts and functions, the philosopher will not hastily decide; but as surely he will not lose sight of them, because they may lead to extended analogies and positive results.

It is moreover impossible not to be struck with the circumstance that the three cerebral lobes correspond to, and are at some points superimposed upon, three other masses in the base of the brain, namely those which in lower animals receive the olfactory nerves and are analogous, as I shall show, to what may be termed the inferior lobes in man, the four tubercles which are placed in the middle part of the brain, and the cerebel which is placed behind. Hence Carus makes the remark that

"the hemispheres, in the three lobes of each side, reproduce the three original cerebral masses, placed one behind the other."*

I have not yet, in this work, systematically considered the functions of any of these parts; but, in order to profit here by the further indications as to the functions of the cerebral lobes, which a slight knowledge of them would afford, I may call the reader's attention to the epithet, original, which Carus here applies to them, because they are the chief parts found in the inferior vertebral animals and the first to be seen in the fœtus. In the animals now mentioned, moreover, the anterior mass receives directly or indirectly an olfactory nerve, and therefore it belongs to the lower perceptions connected with the vital system; the middle mass (tubercles) is intimately connected with involuntary action, as shall afterward be shown; and the third mass is the cerebel or organ of voluntary action.

Compared with these, the cerebral lobes are, as these facts show, superadded parts of higher character, found only in animals of higher function. It seems, therefore, at first sight probable that the anterior lobes bear the same relation to the intellectual system that the anterior mass with which they are especially con-

* An Introduction to the Comparative Anatomy of Animals, vol. i. p. 275.

nected bears to the vital, while at the same time the middle and posterior lobes maintain also some relation to the involuntary and voluntary organs respectively which lie under them.

As, then, the anterior, middle, and posterior lobes have relations of development and position respectively to the simplest and earliest perceptive organ, to the four tubercles, and to the cerebel, so do ideas, emotions and passions, apparently functions of the former, relate respectively to simple perceptions, involuntary action and voluntary action, which are evidently the functions of the latter. The relation of ideas to simple perceptions is obvious, and involuntary actions are as naturally the result of emotions, as voluntary actions are the result of the passions.

Thus the relations of development and position subsisting between the cerebral lobes and the subjacent parts, and the existence of a similar character in the functions of the latter to that which was at first sight suspected in the functions of the former, affords another argument in favour of these lobes being respectively connected with ideas, emotions and passions.

In the third place, the relations which both these series of parts, in their first, second and third portions, bear to the organs of sense and the nerves ascending to them — the circumstance that the nerves of touch ascending from

all parts of the surface appear to pass more directly toward the anterior part of the brain, that the nerves of sight, and perhaps those of smell, pass toward the tubercles, and that the nerves of hearing, and perhaps those of tasting, pass toward the cerebel, while at the same time, as has been already shown, the sense of touch seems to generate ideas, the senses of seeing and smell emotions, and the senses of hearing and taste passions, afford an additional indication that these lobes are respectively connected with ideas, emotions and passions.

Finally, physiognomical observations favour that connexion.

As to the functions of the posterior lobes in particular, it may be observed that, in the quadrumana, exist these lobes, and the posterior horns of the lateral ventricles, which are also, says Tiedemann, the latest parts developed in the brain of the fœtus.*

Now as these parts are the last produced, so are the senses of taste and hearing the last in acquiring delicacy and power of discrimination. It would indeed appear, that with the superiority of taste and hearing corresponds the development of the posterior lobes. This indicates that, as roots of the olfactory, and probably of

* Auch im Fötus bilden sich die Windungen des hinteren Lappen am spätesten.—*Lib. cit. p.* 147.

the optic, nerves pass to the middle lobes, others of the auditory and gustatory nerves pass to the posterior ones.*

* The Wenzels afford a strong case in favour of the connexion of taste with the posterior lobes.

Vicenarius juvenis caelebs pharmaceuta, multa, praesertim botanices scientia instructus, de reliquo tam mira, tamque aliena agebat, ut jure inter homines mentis non satis compotes numerari posset. Bibebat exempli gratia dimidiam vini generosissimi mensuram; qua hausta, tres aut quatuor essentiae stomachicae uncias sumebat, ac denique sex septemve fortis caffeae patellas exhauriebat; et si forsan caloris necessario inde orituri cogitatio subiret, maxima, qua poterat, celeritate duas, aut tres aquae mensuras evacuabat. Comedendi ratio non minus insolens ac portentosa erat. Viginti quinque, ad triginta usque poma, atque exinde jusculi sat bene intriti ingentem portionem saepius absumebat; quin vel de minima molestia inde orta conquereretur. Deambulationes ad duodecim, aut etiam quatuordecim horarum spatium extendebat, cumque domum reversurus, brevissimam viam ab ob viis percontaretur, hac omissa, per trium quatuorve horarum ambages evagabatur.

Subito morbo correptus, ita quidem, ut nullum inde vitae periculum praevideretur; tertio tamen die extinctus est. Rogati, cadaveris sectionem instituebamus.

In cavo pectoris atque abdominis nullum morbosae affectionis signum adparebat.

In cerebro, quod firmum, sed non morbose durum erat, praeter sequentes duas memoratu dignas mutationes, nihil, quod a sana constitutione recederet, detegebatur.

In anteriore scilicet ac media utriusque hemisphaerii cerebri parte gyri admodum magni, longeque a se invicem dissiti ideoque nec tam multi erant, sulcique inter eos siti solito profundiores.

Monkies, accordingly, have a more discriminating sense of taste, if not greater capability of distinguishing musical time, than inferior animals.

It is surprising that writers should not have seen that to this possession of posterior lobes, is due the peculiar elliptical form of the human brain.

The most accurate observers, however, have pointed out that form as the chief external characteristic of the human brain. The Wenzels say, "The difference between the length and the greatest breadth of the brain in man is

In posteriore autem utriusque hemisphaerii cerebri parte gyri tam multi, tam parvi ac angusti, tam varie flexi, tamque arcte sibi adjacentes, sulcique interjecti vix non omnino plani adeo, ut insolita haec ac prorsus singularis varietatum conjunctio summae nobis admirationi esset: gyros quippe tam insigni varietate in uno eodemque cerebro distinctos hactenus nunquam observaveramus.

Altera memorabilis, ex priore manifeste dependens varietas ea erat, quod in utroque posteriore cornu ventriculorum lateralium, quae ceteroquin admodum parva erant, nec minimum tuberis, ibi ut solet siti, vestigium deprehendebatur.

Istius ergo tuberis existentia verisimiliter a certa quadam gyrorum in superficie cerebri sitorum magnitudine, atque certa quadam sulcorum inter gyros jacentium profunditate pendet; pari quoque modo diversa eminentiae istius magnitudo a diversa exteriorum gyrorum magnitudine, atque diversa sulcorum interjacentium profunditate, et si non semper, plerumque tamen pendere videtur. — *De Penitiori Structura Cerebri, p.* 146.

universally greater; in mammalia, less; in birds, least. The brain therefore of man is of all the least round, and that of birds most so."* And Tiedemann concludes "that the brain of man far exceeds the brain of other mammalia in elliptical form."†

It is a remarkable fact and should not be omitted here, that the German brain, or I may perhaps say that of the Gothic races generally, is much more round than that of the Celtic races, and that, conformably with my ascription of passion to the posterior lobes, the former are as deficient in passion and energy as the latter are remarkable for them. Hence, with perfect knowledge of the disgrace of their political condition under their petty jailor princes, the Germans rest inactive; while with less accurate knowledge, the French are yearly sweeping away public robbers and their institutions or constitutions, and the Italians are in incessant activity. As regards the connexion of the posterior lobes with the senses of taste and moving, it may be observed that the French are most recherché in

* Differentia inter longitudinem et maximam latitudinem cerebri in homine universim major; minor in mammalibus; in volucribus minima est.—Cerebrum hominis igitur omnium minime, volucrum autem maxime rotundum est.—*Ibid. p.* 258.

† Inde sequitur, cerebrum hominis figura elliptica cerebrum ceterorum mammalium longe superari.—*Icones Cerebri Simiarum, &c. p.* 48.

the gratification of taste, and the Germans remarkable for coarseness; that the music of Italy is as powerful from its passion as from its grace and beauty, while that of Germany is remarkable for its descriptive and sentimental character, as influenced by the abundant ideas and emotions of their more expanded anterior and middle lobes.

The original craniologists, seduced by the defect of extended posterior lobes being the characteristic of their countrymen, set down the form resulting from it as an excellence.

SECTION IV.

STRUCTURE AND FUNCTION OF THE INTERMEDIATE PARTS.

The posterior striated bodies do not appear to exist in fishes. Reptiles appear to possess them. Birds first clearly present two small eminences of this kind.

Anatomists appear to have been greatly perplexed as to the relation of these to the anterior striated bodies.

The striated bodies, anterior and posterior, are commonly considered as consisting of fibres which with some deviations run on together in the same system to the fibrous cone. Tiedemann occasionally speaks as if the bundles from the peduncles ascended through both striated bodies; and though Reil has kept clearest of

this, because he describes what he saw, yet he perpetually involves both striated bodies in the same general direction—his error being physiological rather than anatomical.

Anatomists appear never to have thought of a descending, as well as an ascending motion, or of the possibility of one of these bodies radiating outward, and the other inward, and they have therefore perpetully treated both as involved in the same course of action.

As, indeed, the anterior striated bodies disperse fibres upward to every point of the circumference of the hemispheres, and as the posterior receive the fibres returning from all these points—as in reality these two pairs of bodies are formed chiefly by the intersection of these fibres ascending and descending—it was a knowledge of this alone that could unravel the complexity.

I shall, at the close of this section, mention the views of these parts which led me to understand them; but, as usual, I shall state those views of others, which occasionally led them nearly to the same conclusion.

It is indeed worthy of remark that anatomists, in their somewhat unconnected tracings of fibres, support the physiological views now given, so far as the structure of the parts is concerned.

Reil observes, that " at the inner side, the posterior striated body is thickest; toward its

outer side, it becomes thinner by degrees; its radiation goes from within outward; *the white fibres proceeding from its whole substance crowd toward its outer side, form there a decussation, and run on together with the fibrous cone.* When, therefore, we cut the cerebral peduncle immediately behind the posterior striated body, raise successively the first, second, and third layer in the dark substance from within outward, and carry the rent even to the outer side of the posterior striated body, it is clearly seen that *the whole outer side itself runs on together with the cerebral peduncle, interweaves, crosses, decussates,* as we find in many places, e. g. the ganglion of the trifacial nerve, *so the fibrous cone is formed above from the posterior striated body, and below from the cerebral peduncle.*"*

* Auf der inneren Seite ist der Sehhügel am dicksten; gegen seinem äusseren Rand zu verdünnt er sich allmählig; seine Radiation geht von innen nach aussen; das aus seiner ganzen Substanz kommende Mark drängt sich gegen seinen äusseren Rand hin, bildet hier eine Nath, und fliesst mit dem Stabkranz zusammen. Wenn man daher den Hirnschenkel unmittelbar hinter dem Sehhügel abschneidet und nun zuerst die obere, dann die zweyte, und endlich die dritte Lage in der schwarzen Substanz von innen nach aussen aufhebt, und diese Brüche bis an den äusseren Rand des Sehhügels fortsetzt, so zeigt es sich deutlich, dass der ganze äussere Rand desselben mit dem Hirnschenkel zusammenfliesst, sich verwebt, kreuzt, eine Nath bildet, wie man sie an mehreren Orten, z. B. am Ganglium des fünften Paars

He also observes that "at the outer margin of the posterior striated bodies *these various structures run together into their pecten, which is a texture woven of the peduncles and posterior striated bodies*."*

Other observations of Reil on the structure of the connected parts, show that he found the cerebral expansions of the posterior striated bodies distinct from those of the anterior ones, both *mesially* and *laterally*.

"The foremost bundles (of the fibrous cone)," he observes, "go in a straight direction towards the great commissure; but those which are next, lying backward toward the middle, bend with their extremities, so that their curved portion lies behind the others. This takes place in the apparently structureless layer which lies at the outer side of the anterior striated body, and runs backward with the semicircular line. This occurs only internally in the ventricles; externally in the capsule, the radii do not depart from their straight direction. With this consequently is connected the circumstance that *the outer layers of the fibrous cone are formed*

findet, der Stabkranz also von obenher von den Sehhügeln und von untenher von den Hirnschenkeln gebildet wird.—*Archiv für die Physiologie, Neunter Band*, p. 155.

* Am äusseren Rande der Schhügel fliessen alle diese Organisationen in ihren Kamm zusammen, der ein Gewebe der Hirnschenkel und der Schhugel ist.—*Ibid.* p. 518.

*from the cerebral peduncle, the inner from the white fibres of the posterior striated body.**

"At the outer wall of the inferior horn," he observes, "lie thus under the epithelium, first the tapetum formed from the great commissure and semicircular line; then *a thick layer derived from the obtuse end of the posterior striated body; and finally a layer derived from the cerebral peduncle and the anterior commissure.*"†

Again, "To show the organization in the inferior horn, we must previously raise the optic tracks, divided at their commissure, even to their geniculate body, and then expose *the obtuse posterior extremity of the posterior striated*

* Diese ersten Stäbe gehn in gradlinigter Richtung gegen den Balken fort, aber die nächsten, gegen die Mitte rückwärts liegenden krümmen sich mit ihren Extremitäten, so dass einer bogenförmig hinter dem andern liegt. Dies geschieht in der scheinbar structurlosen Masse, die am äussern Rande des gestreiften Gangliums liegt, und hinterwärts mit der Taenia zusammenfliesst. Es geschieht nur inwendig in den Hirnhöhlen, auswendig in der Kapsel weichen die Strahlen nicht von ihrer geraden Richtung ab. Ob dies damit zusammenhängt, dass die äussere Fläche des Stabkranzes vom Hirnschenkel, die innere von den Markproductionen des Sehhügels gebildet wird?—*Ibid, p.* 164.

† Auf der äussern Wand des Seitenhorns liegt also unter dem Epithelium zuerst die Tapete, die von dem Balken und der Taenia gebildet wird, dann ein starkes Stratum von der bedeckten kulbigten Extremität des Sehhügels, und endlich eine Lage, die vom Hirnschenkel und der vördern Commissur gebildet wird.—*Ibid. p.* 165.

body lying under them, which radiates under the tapetum into the inferior horn. Through these means are brought into view at once *the outer and upper bundles of the cerebral peduncles, which bend backward abruptly, expand under that layer,* and run on together with it."*

It is scarcely possible for any thing to show more clearly the relations of the anterior and posterior striated bodies as to structure; and though this excellent anatomist entirely lost sight of this, by describing the fibres of these bodies as running in the same general course toward the cerebral convolutions,—instead of exactly opposite courses—one, namely, toward, and the other from, the convolutions, yet his facts are entirely in favour of the exposition both of the structure and function which I gave in the same year, 1809.

Twelve years after this, appeared the first work in which any writer extricated himself completely

* Um die Organisation im Seitenhorn zu Gesicht zu bringen, muss man vorher die in ihrer Commissur zerschnittenen Sehnerven bis an ihr corpus geniculatum aufheben, und die zweyte unter ihnen liegende kulbigte Spitze der hintern Extremität des Sehhügels frey machen, welche sich unter der Tapete strahligt im Seitenhorn ausbreitet. Dadurch kommen zugleich die äussersten und obersten Bündel des Hirnschenkels zu Gesicht, die sich stark rückwärts krümmen, sich unter jenes Stratum ausbreiten, und mit demselben zusammenfliessen.—*Ibid. p.* 170.

from the error of confounding, as to structure at least, the posterior and anterior striated bodies. This was a Paper in the "Memorie della reale Accademia delle Scienze di Torino," vol. 29, which Rolando himself translated into French under the title, "Recherches Anatomiques sur la Moelle Alongée, par L. Rolando, Professeur d'Anatomie, Lues à l'Académie de Turin dans la séance du 29 Décembre 1822."

He there says, "The pyramidal bundles, however, do not form the whole thickness of the cerebral peduncles, but only their anterior and external part, for their fibres, in issuing from the cerebellic ring, are separated from the more internal parts by a quantity of dark substance, in such a way that I do not believe that they contribute to form the posterior striated bodies, as MM. Gall and Spurzheim have asserted. . .In this manner, as I have said elsewhere, *the pyramidal bundles pass forward, or leave on one side the posterior striated bodies, and traverse the anterior striated bodies alone.*"*

* Les faisceaux pyramidaux cependant ne forment pas toute l'épaisseur des pédoncules cérébraux, mais seulement leur partie antérieure et externe, puisque leurs fibres, en sortant de la protubérance annulaire, sont séparées des parties les plus internes par un amas de substance noirâtre, de manière que je ne crois pas qu'elles concourent à former les couches optiques comme MM. Gall et Spurzheim l'ont avancé. . .De cette manière, ainsi que je l'ai dit

In a still later work, which appeared in 1829, he more fully explains this matter; observing that "the layer coming from the posterior striated bodies, ascends between the layer of the peduncles and of the internal portion of the anterior striated body, even to the height of the great commissure, where its fibres bend inward, leaving those of the peduncles, direct themselves horizontally toward the median line, and pass under the raphe to meet those of the opposite side, and form the commissure."*

And again in the same work, "The fibres which radiate from the external margin of the posterior striated bodies, when they meet those ascending from the peduncles, form a white plate four or five lines in thickness, which rises between the external and internal portions of the anterior striated bodies, since the external rests upon the fibres of the peduncles and the

ailleurs, les faisceaux pyramidaux passent au-devant, ou laissent de côté les couches optiques, et traversent seulement les corps striés.

* Lo strato proveniente dai talami ascende in mezzo allo strato dei pedoncoli, ed al corpo striato interno sino all' altezza del corpo calloso, ivi le sue fibre si piegano indentro lasciando quelle dei pedoncoli, e si dirigono orizzontalmente verso la linea mediana, passano sotto il raphe per incontrarsi con quelle del lato opposto, e formare il corpo calloso.—*Della Struttura Degli Emisferi Cerebrali*, p. 24.

internal on those which go from the posterior striated bodies, to the great commissure."*

Rolando goes too far, however, in describing the fibres of the two striated bodies as altogether distinct, because he looks chiefly to the sides where they are free, and he even mistakes the arches in which they interlace in successive layers for a gangliform appearance.

It is in consequence of these relations between the advancing and returning fibres that the foremost bundles of the fibrous cone appear to meet those of the great commissure at right angles, the middle bundles, to become directly continuous with the latter, and the posterior, to be extended in a separate layer above them.

Having thus shown the *independence* of the anterior and posterior striated bodies, I may observe that the size of the posterior striated bodies is in a direct ratio to that of the cerebral lobes and in the inverse ratio of the tubercles, in reptiles, birds, mammalia and man. Gall terms them the great cerebral ganglia, to distin-

* Le fibre che sortono a guisa di raggi dal margine esterno dei talami, mentre s'incontrano colle ascendenti dai pedoncoli formano una lamina midollare di 4 a 5 linee di grossezza, che s'innalza fra mezzo ai due corpi striati, poichè l'esterno è appoggiato sulle fibre dei pedoncoli, e l'interno su quelle, che dai talami vanno al corpo calloso.—*Ibid. p.* 24.

guish them from the anterior striated bodies, which he names the lesser ganglia.

This greater magnitude of the posterior than of the anterior striated bodies, again illustrates my former observation that, throughout the nervous system, the posterior and descending are larger than the anterior and ascending parts,—as is the posterior than the anterior part of the brain, the posterior than the anterior peduncles of the cerebel, the posterior than the anterior roots of the spinal nerves,—affording an analogical proof of another kind, that my ascription of functions is accurate.

I proceed now to show, that the *connexion* which I, twenty-five years ago, traced between the posterior striated bodies and the superior peduncles of the cerebel, is confirmed by the detached observations of contemporaneous or subsequent writers.

Reil traces the uniting fibres of the posterior striated bodies into the superior peduncles of the cerebel; but, it is to be observed, that, unaware of the course of their action, he as usual inverts it, and instead of tracing the fibres of the posterior striated bodies backward into the peduncles, he speaks as if the peduncles went forward to the posterior striated bodies. This error, however, is here of no consequence: it is the fact of connexion that is wanted.

The anterior peduncles, he says, now plunge, immediately behind the posterior striated bodies, into the upper mass, forward, inward, and downward, being covered on the outer side by the fillet, on the inner by the round bundles, and their accompanying grey substance, which they embrace on both sides by means of their ansa or handle. Below the round bundles, they free themselves on both sides and form an ansa, which is several lines thick and constitutes the upper wall of the foramen cæcum. It is a question whether in the middle a decussation occurs. Above this ansa, as already said, is the course of the round bundles; underneath it the deeper seated parts of the upper mass, and the foremost bundles of the vertical layer.* From the ansa radiations pass in the form of thin plates forward, and surround a mass of grey substance in the inner and posterior part of the posterior striated bodies, covered by their caps, immediately upon the cerebral peduncles,—a mass which lies before the ansa, touches the wall of the third

* Elsewhere he says, "at the floor of the passage from the third to the fourth ventricle, lie the round bundles; below these, the ansa of the anterior peduncles of the cerebel; and then the remainder of the upper mass upon the peduncle, of the brain."—Im Grunde der Wasserleitung liegen die runden Bündel, unter denselben die Ansa der vörderen Schenkel, und unter diesen geht der Rest der Haube auf den Hirnschenkeln fort.—*Lib. cit. p.* 516.

ventricle, and has before it the root of the arch.*

Again he says, that below the fillet, the anterior peduncle of the cerebel extends sideward from the floor of the passage from the third to the fourth ventricle, runs from without inward and downward toward the dark substance, and goes then probably both to the radiation of the vertical portion and above the posterior striated body.†

* Nun dringen die vörderen Schenkel unmittelbar hinter den Vierhügeln in die Haube ein, vorwärts, einwärts und abwärts-gehend, auf ihrer äusseren Fläche von der Schleife, auf der inneren von den runden Bündeln und der dieselben begleitenden grauen Substanz bedeckt, welche sie mittelst ihrer Ansa von beiden Seiten umfassen. Unter den runden Bündeln münden sie von beiden Seiten, und bilden eine Ansa, die mehrere Linien dick ist, und die obere Wand der Grube für das dritte Paar bildet. Ob sie in der Mitte eine Nath hat?..Ueber sie weg gehn, wie schon gesagt, die runden Bündel, unter ihr durch die tiefer liegenden Theile der Haube und die vördersten Fasern der senkrechten Schicht...Von ihr laufen Radiationen in der Form dünner Blätter vorwärts und umfassen einen kugligten Klump grauer Substanz, der inwendig und im hinteren Theil der Sehhügel, bedeckt von ihrer Kappe, unmittelbar auf den Hirnschenkeln, vor jener Ansa liegt, an die Wand der dritten Hirnhöhle gränzt, und vor sich die Wurzel der Zwillingsbinde liegen hat.—*Ibid. p.* 511.

† Unter der Schleife läuft der vördere Schenkel des kleinen Gehirns, seitwärts von dem Grunde der Wasserleitung fort, dringt von aussen nach innen und in die Tiefe gegen die schwarze Substanz zu, und geht dann wahrscheinlich auch in die Radiation des Hirnschenkels und der Sehhügel über. —*Ibid. p.* 153.

By this means, *the posterior striated bodies are continued into the superior peduncles of the cerebel.*

Similarly inverting the order of function, but as distinctly tracing the connexion of parts, Tiedemann says, at seven months, the superior peduncles of the cerebel, penetrate forwards and outwards into the tubercles, and proceed directly forward. Their fibres are covered on the outer side by the oblique ascending fibres of the olivary bundles. These parts are enveloped, both on the inner and outer side, with unfibrous substance. After having cautiously removed this exterior unfibrous layer, we perceive this direction of the fibres both of the olivary bundle and of the superior peduncle of the cerebel. *Many of these fibres pass forwards into the posterior striated bodies.**

Taking a point of this course still further backward, but always inverting the course of its

* Letztere die Schenkel des kleinen Hirns zu den Vierhügeln dringen von hinten und innen in die Vierhügel ein, und laufen nach vorn. Ihre Fasern werden von aussen von den schräg aufsteigenden Fasern der Olivarstränge bedeckt. Diese Theile werden sowohl von innen als von aussen mit einer faserlosen Substanz bedeckt. Nimmt man die äussere Schichte faserloser Substanz behutsam weg, so erblickt man den angegebenen Verlauf der Fasern, sowohl der Olivastränge als der Schenkel des kleinen Hirns von den Vierhügeln. Ein grosser Theil dieser Fasern setzt sich nach vorn bis in die vermeintlichen Sehhügel fort.—*Anatomie und Bildungsgeschichte des Gehirns, p.* 64.

functions, which with him was no object of consideration, Reil says, the anterior extremity of the peduncle crosses below the olivary bundle, inclines rather downward and inward, forms the anterior margin of the lozenge-like field, completing, in connexion with its body and the medullary velum, the sloping roof of the fourth ventricle. Again he says, that the opposite and posterior extremity of either superior peduncle extends below the roller-like substance into a hemisphere of the cerebel.†

Proceeding in the same inverted order, Tiedemann says that, at eight or nine months, the rhomboidal bodies [of the interior of the cerebel] give origin to the superior peduncles; each of which passes forwards into the corresponding half of the common mass of the tubercles, and is covered by the fibres of the olivary bundles, proceeding upwards and inwards.

Approaching still nearer the cerebel, and considering the peduncles now as passing toward the cerebel (the very reverse of all he had before said in this respect, in consequence of his having no notion of function, as this discrepance proves), Reil says, the superior peduncle, which is contracted at the point where it disappears, now extends directly backwards; spreads laterally, and

† Mit der entgegengesetzten und hinteren Extremität dringen die vörderen Schenkel unter der Wulst in die Hemisphärien des kleinen Gehirns ein.—*Lib. cit. p.* 513.

divides into packets; and appears to enclose some portions of the ciliary body, to penetrate, and even to terminate in them.

These anterior peduncles of the cerebel, as these writers have shown, are flat, and resemble in structure the olivary bundles, or the arch; their fibres being, like those of the arch, flax-like, delicate, and distinct, and their general direction longitudinal: they decussate each other laterally, and thus doubly unite the brain and cerebel.

From the details which have now been given in this section, it becomes very evident, that, notwithstanding their not being aware of the relations between the anterior and posterior striated bodies, and their not duly distinguishing the course of their fibres, yet the most accurate and trustworthy observers state the isolated and simple facts which occasional views of the parts presented to them, so as completely to verify my statement that "from the hemispheres, it [the medullary matter or cerebral bundles] passes backward, inward and downward, through the thalami [posterior striated bodies], backward through the striæ inferior to the nates and testes [tubercles], and backward and upward through the processus cerebelli ad testes or the anterior peduncles of the cerebellum, to the substance of the cerebellum itself."

It was this view that, so early as 1809, un-

ravelled to me much of the structure of the organ, even without the aid of any hardening process.

In making a section of the posterior striated body, I then observed, that the divided striæ appear most numerous toward its upper and outer, and much more scattered toward its inner side ; and, in dividing still downward, a section of the peduncle of the brain appears interiorly. By making a second section about the middle of the posterior striated body, its exterior superior filaments appear to unite into a denser semicircular form, the convexity of which is still toward its outer and upper side, and, at the lower part of which the peduncle appears still more distinct. By making a third section, this arrangement becomes still more evident, but, at the same time, more contracted, and passes more toward the inner and under side of the tubercles, gradually approaching the anterior peduncle of the cerebel. A horizontal incision also, if made immediately below the level of this semicircular track, shows that the striæ of the posterior striated bodies terminate in a longitudinal bundle, which passing inferiorly and interiorly to the tubercles, terminates in this peduncle. Thus are the brain and cerebel connected by the white or medullary substance.

These observations, then, are now confirmed

by those of Reil, Rolando and Tiedemann, and unquestionably the more confirmed thereby that these anatomists, in the passages I have quoted, as well as throughout their works, show, by describing the structure generally in an order directly opposed to that of its function, that they had no idea of the course of action in these parts.

As to the time of the appearance of these peduncles, Tiedemann says "the superior peduncles of the cerebel and the anterior valve, appear even at the end of the third month, as a delicate plate, which, detached from the anterior thin border of the cerebel, joins the posterior margin of the membranes which bend up to form the common mass of the tubercles. According as the ciliary bodies are developed, these peduncles also become more voluminous."*

Thus the formation of these posterior or returning bodies just precedes the motions of the fœtus.

* Die vorderen Schenkel des kleinen Hirns zu den Vierhügeln (crura s. processus cerebelli ad testes) und die grosse Hirnklappe oder das vordere Marksegel Reils erscheinen schon zu Ende des dritten Monats als ein zartes Blättchen, welches von dem vorderen zarten Rand des kleinen Hirns ausgehend, mit dem hinteren Rande der nach innen umgebogen Vierhügelmembranen verbunden ist. So wie die Markkerne an Grösse zunehmen, werden auch die Schenkel zu den Vierhügeln vermehrt.—*Lib. cit.* p. 108.

If the course of action in these parts be still doubted by any one, the only further answer I need make is brief: if the functions of the anterior bundles have been accurately assigned, and the proof thereof is irrefragable — if the anterior be the ascending bundles — the cerebral action can be continued to the cerebel in no other way than that which is now described.

There can, I believe, be no better vindication of the accuracy with which I stated, in 1809, that "from the posterior part of the medulla of the hemispheres, it [the cerebral action] returns by the thalami, passing backward, inward and downward; flows backward in the fasciculi under the nates and testes; and upward through the processus cerebelli ad testes or anterior peduncles of the cerebellum; and thus reaches the medulla of the cerebellum itself."

SECTION V.

STRUCTURE AND FUNCTION OF THE CEREBELLIC PARTS.

In fishes, the cerebel is often larger than the cerebrum, and is sometimes accompanied by additional ganglia.

Tiedemann observes that the degree of evolution in which we find the cerebel in the fœtus of the third month, is similar to the permanent state observed in osseous fishes, in many

of the cartilaginous, and in the greater part of reptiles.

In birds, the cerebel still resembles only the vermiform or central portion of the same part in man, and wants the superadded lateral parts which are found in higher animals.

In mammalia, the cerebel is more highly developed. It consists of a central mass and two lateral lobes, less conspicuous in the rodentia than in the superior species, and most so in apes and the porpoise. Of these, the middle or vermiform portion, so small in man, is usually very large ; the fore part only of the cerebel possessing distinct wings ; and there being, laterally and behind, only off-sets. In proportion, says Reil, as the fabric improves, the off-sets are changed into wings, till at length in human beings the hemispheres are completed.

That the size of the cerebel has little to do with the degree of sexual appetite is rendered very evident by the smallness of the cerebel in frogs, which are yet remarkable for salacity.

Willis thought the cerebel the organ of involuntary motion, as stated in the Preface. I am convinced that he was further wrong than I imagined when the paper there quoted was written, and that the cerebel is the organ only of voluntary motion. This, as well as the means by which involuntary motion is performed, will appear in the sequel.

Haller says it appears that, upon the whole, the cerebel in so far differs little from the brain (collectis omnibus, videtur cerebellum et a cerebro hactenus parum differre), and concludes that the brain seems to send both feeling and moving power to the vital organs, while the cerebel sends both feeling and moving power, to the parts which are subject to the will (deinde cerebrum ad vitalia organa et sentientem vim et moventem mittere, et ad partes mentis arbitrio subjectas cerebellum).—It will be here seen that the brain sends neither sensation nor motion to any part, but merely receives a continuation of sensitive motion from the organs of sense; while the cerebel has nothing to do with sensation, but sends motion to the voluntary parts.

I shall now state some of my reasons for asserting that the organs of sense being those of sensation, and the brain that of mental operation, the cerebel is the organ of volition.

1. There are three distinct intellectual organs or classes of intellectual organs, namely, the organs of sense, the brain, and the cerebel.—That the cerebel, though separated from the brain only by membranes in man, is not on that account less distinct from it than are organs of sense separated by bony plates, is rendered evident by the consideration, that membranes

form, in the one case, as effectual a separation as bony plates do in the other; that many animals have a bony tentorium between the brain and the cerebel, as they have bony plates between the brain and face; and that others (birds) have membranes between the brain and face, as they have a membranous tentorium between the brain and cerebel.

2. There are three distinct mental functions or classes of mental function, namely, sensation, intellect, and volition.

3. Of these organs, those of the senses are first, the brain intermediate, and the cerebel the last.—For although the face, containing the organs of sense, and the cerebel, are, in different animals, very differently placed with regard to the brain, yet there is a peculiar relation between the situation of one of these and that of the other with regard to it. In other words, although the face is sometimes in one situation and sometimes in another with relation to the brain, yet, to each variation of its situation with regard to that body, there is a corresponding and uniformly accompanying variation in the situation of the cerebel. Thus as, in man, the face is placed below the anterior part of the brain, so is the cerebel placed below its posterior part, and precisely as, in the inferior animals, the face advances, precisely so does the cerebel recede, till, in those

animals in which the face is placed exactly before the brain, the cerebel is placed exactly behind it.*

4. Of the functions, sensation is the first, mental operation intermediate, and volition the last.—That sensation precedes and excites, if it do not generate, mental operation, few will deny; that mental operation, however rapid or evanescent, precedes and excites volition, or that the motive to an action must precede the action, none will refuse to allow; and that, of any one series of mental action, volition is the last stage, all must admit.

5. As, then, the cerebel is the last of the mental organs, and volition the last of the mental functions, and as, at the same time, there is no organ without function, or function without organ, it follows, that the cerebel must be the organ of volition.

6. In perfect conformity with this truth, the inferior animals, however defective in intellect, possess motion; and in almost all of them which have any visible nervous system, a cerebel, the organ of that motion, exists.—This leads me to an observation which seems to me to possess

* The cerebellic cavity, moreover, seems uniformly to commence on the inside of the base of the cranium exactly opposite to the place where the face or the lower jaw terminates on the outside.

considerable interest and beauty. As we descend among animals, one of the three portions of the nervous system and one of its three general functions gradually disappear. Now it is not the first and the last portions of the nervous system—it is not the organs of sense and the cerebel, neither is it their respective functions, sensation and volition, which are thus lost. It is the brain and mental operation which are lost. This organ is, among men, most conspicuous in the Caucasian race; and we accordingly find that that race alone has cultivated the sciences. It is less even in the Mongol and Ethiop, who have ever disregarded them. It gradually disappears, as we descend among quadrupeds, birds, reptiles, fishes, &c., and with it gradually disappear the powers of thought. But organs of sense and a cerebel, sensation and volition, yet remain to distinguish myriads of animals below these.

7. This truth receives new confirmation when we observe, that the degrees of voluntary power always bear a close analogy to the various magnitudes of the cerebel.

As in animals having a series of ganglia like the earth worm, the anterior ganglia controul the rest of the body (for if such an animal be divided, the anterior part preserving its motion, will move on, while the posterior remains without an object) it seems that an anterior ganglion

directs the motions or performs the functions of a cerebel.

The gadfly is said to exercise the most rapid motions, but scarcely to possess perception; and this is probably owing to its cerebellic ganglion and its want of anything analogous to a brain.

In some fishes which possess amazing locomotive power, the cerebel is often larger than the brain. The rays and sharks afford examples of this. They sometimes also have lateral appendages to the cerebel, as in the haddock; occasionally, a single ganglion below it, as in the carp, which seems to Cuvier a second cerebellum; and sometimes, other ganglia behind it, as in the herring, &c.

The cerebel, however, is evidently the less in fishes and reptiles, that their motions are greatly dependent on their spinal cord, the brain generally being of less importance to them. The buoyancy, moreover, of the medium in which fish are immersed diminishes the necessity of muscular exertion. The specific gravity of fish is nearly equal to that of the liquid which they inhabit; and their movements are of course performed with the exertion of little force.

The cerebel is small in reptiles, which are sluggish, especially in frogs and serpents.

The cerebel is large in birds, which are very active.

In mammalia, the bulk of the cerebel is

greater in proportion to the rest of the brain than in man.

The difference, say the Wenzels, between the length and breadth of the cerebel, and the length and breadth of the brain in man is universally greater than in animals; whence the cerebel of animals is greater compared with their brain than the cerebel of man is compared with his brain.*

On the same subject Tiedemann says, that the breadth of the cerebel compared with its length in the middle part is much greater in man than in simiæ and other animals.† This is owing to the development of the hemispheres in man.

This corresponding development of the cerebel and display of voluntary power seems indeed to be founded upon a general principle; for if, as already said, we compare this organ in birds or quadrupeds, we generally find it large in proportion to their more intense, frequent, and rapid voluntary motion. If, however, we compare this part in the genera and species of ani-

* Differentia inter longitudinem latitudinemque cerebelli et longitudinem latitudinemque cerebri in homine in universum major, quam in dictis animalibus est; unde cerebellum animantium illorum comparate ad cerebrum majus est, quam cerebellum hominis ad cerebrum ipsius.—*De Penitiori Cerebri Structura, p.* 258.

† Latitudo cerebelli cum longitudine in parte media comparata multo major est in homine quam in simiis et reliquis mammalibus.—*Icones Cerebri Simiarum, etc.* p. 52.

mals, we must attend not only to the general magnitude of the organs, but to their particular form; for, as I have already shown, "on the length of the cerebral organs depends the intensity of their function, and on the breadth of these organs, the permanence of their function."

As liquids pass with greater velocity through the narrow portion of a tube than through its wider parts, precisely so must all nervous action pass between the parieties of the organs—the tubes of the neurilema, whether that action be performed by aeriform fluids, by liquids, or by globules. That the nervous matter is thus laterally confined by the neurilema, is proved by the circumstance of the ends of nerves expanding when cut, and they are, therefore, in so far subject to similar laws with liquids contained in tubes.*

This important fact may be illustrated from the classes of animals; for the laterally compressed and high cerebel of birds corresponds admirably with the intensity of their voluntary

* It is perhaps also for the same reason, that in a galvanic battery, the intensity of its action seems to correspond with the number of plates (for the igniting power is as the number), and the permanence of its action with the magnitude of the plates. Accordingly, M. de Luc observes, that the number of the plates is analogous to the length of a pump for raising water; and the size of the plates is analogous to the magnitude of the bore of the pump.

powers, and the depressed and flat cerebel of the turtle, frog, salamander—in short, of all the slow but long moving reptiles, equally corresponds with the permanence of their voluntary power.

It is from not distinguishing between the height and the breadth of the organs, and their corresponding intensity or permanence of function, that such comparisons and the scales founded upon them are of diminished value, and inapplicable to the present question.

There are other sources of error in such more minute or limited comparisons, arising from this, that, both in the brain and the cerebel, certain parts, existing in very different proportion in different animals, are subservient to the sensations and motions of the vital system.

Will directs nervous power not merely toward muscles, but that in various ways, as either directly, or by substituting voluntary for involuntary action.

The objections of Dr. Fleming on this subject, I have answered in the preface, to which the reader is requested to refer.

The preceding doctrine, therefore, conforms to Cuvier's observation, that "on comparing together all the nervous systems, we find only one common part which is a single tubercle, situated at the anterior extremity of the system, and always producing two lateral and transverse

bundles or peduncles which unite it to the rest of the system.—This part appears also to correspond to that named cerebel in man."

I have next to notice the experiments of Magendie, &c., on the cerebel, and to show that even they confirm the doctrine now delivered, although they have not been understood by the experimenters on living animals.

"Rolando," says Magendie, "removed the cerebel from several quadrupeds and birds, and he observed that the movements diminished in the ratio of the quantity of substance subtracted : he affirms that all motion ceases when the whole organ is extracted.

"Although the fact announced by M. Rolando has often presented itself to my observation, [many years no doubt after stated by Rolando], I cannot admit the explanation of it which he offers ; for I have seen, and have demonstrated to others, a great many times, in my course of lectures, animals deprived of the cerebel, and which nevertheless executed very regular movements."—This, as I shall forthwith show, was because those organs remained, upon which involuntary motion depended.

"I have seen, for instance, hedgehogs and guinea-pigs, deprived, not only of the brain, but also of the cerebel, yet rubbing their noses with their paws in front, when I put a cruet with vinegar under their nostrils."—It is precisely in

affections of the organs connected with vitality, that involuntary actions are caused.

"Now a single positive fact is here of more value than all the negative observations put together; and let no one suppose that there remained any doubt of the entire removal of the cerebel; the operation was performed in a manner that left no room for the least uncertainty." —The fact is not doubted; but it is worthless, seeing that the organs of involuntary motion remained.

"These experiments correspond also to another idea proposed by a young French physiologist, M. Flourens, who assigns to the cerebel the property of being the regulator or balance of animal motion."—A regulator as well as an organ of motion, is nonsense, and has no existence.

"A fact which has been observed by all persons who have made experiments on the cerebel, is that lesions of that organ cause animals to move backwards, and even to perform that motion contrary to their inclination. I have often seen animals, when wounded in the cerebel, make an effort to advance, but immediately they have been compelled to retrograde." —This motion backward, though not understood by these experimenters, is in the direction of the natural motion which I have just stated to prevail in the part.

"I preserved for eight days a duck from which I had removed the greater part of the cerebel, and which made no progressive movement during all that time, except perhaps when I placed it in water."—That, after the removal of the cerebel in a bird, irritation causes it to walk, or that being thrown into the air it moves its wings regularly and alights upon its feet, or that when placed in water, it swims, is evidently owing to the bundles on which depends involuntary motion remaining uninjured.

"I have likewise seen injuries of the medulla oblongata produce retrograde motion, so that I think this ought not to be referred exclusively to wounds of the cerebel. Pigeons into which I had forced a pin through that part, constantly moved backwards, in walking, for more than a month, and even flew backwards, a singular movement, and which is most remote from the usual locomotion of that bird."—If these pins were forced into the posterior part of the oblong process, the retrograde motion was in the direction of the natural motion which I have just stated to prevail in the part.

"This impulse of retrogression exists only in mammalia and birds. I have often removed the cerebel of fishes, and what is named the cerebel in certain reptiles, and I have never seen any thing which resembled the phenomena of which I have spoken above. Those crea-

tures continued their progressive motions, as if they had not been touched."—Evidently because their motions are more dependent on the spinal cord, and more extensively involuntary.*

"If one of the peduncles of the cerebel is divided in a living animal, the animal begins immediately to roll laterally upon itself, as if it were impelled by a great force; the rotation is made upon the side where the peduncle is cut, and sometimes with such rapidity, that the animal makes more than sixty revolutions in a minute."—This lateral motion is in the direction of the natural motion which I shall afterwards show, prevails in the part.

"The same sort of effect is produced by all the vertical sections of the cerebel which embrace from before backwards the entire thickness of the medullary arch which it forms above the fourth ventricle, with this remarkable circumstance, that the motion is so much the more rapid, as the section is nearer to the origin of the peduncles, in other words, to their commu-

* This is another remarkable proof that whatever peculiarity is found in Müller's experiments, is owing to the peculiar organization of the animal on which they were performed; and it strikingly shows *the danger of drawing general conclusions as to the nervous system of man from experiments on frogs, in which the third great portion of that system, the cerebel, is wanting! and the spinal chord may be deemed an independent organ!*

nication with the transverse ring."—The same reply is here applicable.

"All the vertical sections made from before backward upon the transverse ring, produce the movements of rotation which have been described, and in a similar manner. The sections made to the left of the median line, determine the rotation to the left, and vice versa. I have never been able to succeed in making a section exactly along the median line, so that I know not whether the same thing obtains of this in the pons as in the cerebel."—The same reply is here applicable. But M. Magendie's explanations by the supposition of various *spontaneous* [this word is perhaps intended to mean causeless] impulses or energies, is at once wildly hypothetical and unnecessary.

"In the different experiments from which I have drawn these consequences, the animals became a sort of automatons fitted up to execute such and such motions, and were incapable of producing any other."—This no doubt shows, that the cerebel is the organ of motion, as I had stated thirteen, and Rolando twelve years before. But such proofs were quite as unnecessary, as they were misunderstood, by the experimenters on living animals.

"A movement in a circle, from right to left, resembling that of the manege, shows itself upon a section of the oblong process, made so

as to affect that portion of it which approaches the outside of the anterior pyramid. In order to perform this experiment, I employed a rabbit of three or four months, and exposed the fourth ventricle; then, raising the cerebel, I made a perpendicular section to the surface of the ventricle, and from $1\frac{1}{2}$ to $1\frac{4}{5}$ of a line, on the outside of the median plane. If I cut on the right side, the animal turned to the right; and to the left, if I made the incision on that side."—The same reply is applicable here, as to all these experiments on the cerebel, inducing motions in particular directions.

It is remarkable that the direction in which animals move or turn on cerebral parts being cut, is always in the precise course which I have assigned to the action of these parts.—When an animal turns backward on the upper part of the cerebel being removed, it is evidently because the general cerebellic motion is at first from before backward and the fasciculi are in this case cut before any particular direction is impressed upon it.—When an animal turns to the injured peduncle, or part of the cerebel from which the peduncle descends, it is evidently because the cerebellic motion in that part descends toward the ring—and so on as to other cases.

To the distinction as already stated, of the nerves as forming two classes, namely, those of sensation and those of volition, the writer was, in

a great measure, led by the fundamental fact just now stated as to the cerebel; for he could not see in it an organ of volition, without concluding that the nervous cords connecting it with the muscles belonged to the same function, and must be totally distinct from those which connect the organs of sense with the cerebrum or greater brain and which therefore transmit sensations.

Volition, then, would appear to consist in the transmission of the impulse from the cerebel, the new modification which, from its structure, that impulse must undergo, and its rapid descent through the posterior columns to the muscular organs.

The convolutions of the cerebel stand doubtless in the same relation to voluntary motion, that those of the brain stand to perceptions, and this or that convolution will give guidance to corresponding muscles.

That the particular muscles to be employed and the direction of the motions thus depend on the cerebel, is evident even from the various directions which injury of that organ causes.

Flexors and adductors perhaps act in general with desire; extensors and abductors, with aversion:—or anterior and internal muscles, with desire; posterior and external, with aversion. The local action in the cerebel exciting one or other, doubtless depends on the part of the brain whence excitement is received. And that

probably depends in general on the combination formed between intellectual and vital perception, &c.

Hence, volition must be implicitly dependent on intellectual operation, as that is dependent on sensation, and it, upon external impression.

SECTION VI.

STRUCTURE AND FUNCTION OF THE DESCENDING PARTS.

That volition must be communicated to the muscles by nerves in which the action is descending or from the brain, is so obvious as not even to admit of elucidation.

That the posterior columns of the spinal cord are its descending columns, and the posterior bundles of the spinal nerves are their descending bundles, is proved by the following among other considerations :—

1st. Voluntary action must be the result of will, as that is of previous intellectual processes; and, accordingly, the posterior roots of the spinal nerves join the posterior columns of the spinal cord, and these are directly connected only with the cerebel, which acquires superadded parts and a general increase, with the increase of voluntary and muscular powers, and appears therefore to be their organ.

2dly. While the posterior columns, by means

of the restiform bodies, come directly from the cerebel, so do the two nerves, the facial and the external oculo-muscular, which are chiefly motive, come either from that organ, or parts immediately dependent on it, and pass through all the anterior parts. Now, of these nerves, we know that the impressions must be descending, for they are nerves chiefly of volition. If, then, ascent and descent, or sensation and volition, be respectively communicated by the spinal columns, the latter must be communicated by those columns of which the origins are joined by nerves of volition.

3dly. The development of organization, as already said, corresponds with the activity, the intensity or the permanence of function. Now, in the fœtus, all the posterior parts (cerebral and cerebellic masses, peduncles and columns) are developed after the anterior, as the facts quoted from Tiedemann prove. Correspondingly, descending action or volition absolutely must follow ascending action or sensation; and, accordingly, it is, as already said, precisely at the completion of the first feeble development of the posterior parts, as the facts quoted from Tiedemann also prove, that the first motions of the fœtus are felt. It is scarcely possible to have a more decisive proof that the posterior peduncles, columns and nerves are those of volition.

4thly. The posterior columns and nerves are alone susceptible of pain, which appears uniformly to be connected with descending, motive, and probably vital parts; while, on the contrary, it appears to be a law of the system that all anterior and ascending parts, being those of specific sensation, are unsusceptible of pain, as is the case with the olfactory, optic and auditory nerves, the hemispheres, great commissure, &c.

5thly. In living animals, motions cannot be excited by irritation of the posterior columns and nerves; and this conforms to the apparent law, that there is no motion without previous sensation. The latter can alone induce the voluntary or involuntary impulse, which we know not how artificially to simulate. As, therefore, the production of motion by irritating a nerve, is a test of its being a nerve of sensation, so the non-production of motion by direct irritation characterizes motive nerves.

This doctrine, as we proceed, will receive additional verifications both from connected views, and from the labours of others.

Reil has shown that on each side "the inferior peduncle passes with the anterior edge of its stem between the superior and lateral ones, [inverting then, as he frequently does, the order of functional succession] lays itself like an inner and advancing plate against the lateral peduncle, which together, throw themselves as an arch over

the superior peduncle and the adjoining anterior valve, and unite with their fellows in the superior vermiform process,"*—instead of saying that from its union with its fellow in the superior vermiform process, it throws itself over the root of the superior peduncle and the adjoining anterior valve.—Thus the posterior peduncles of the cerebel become the restiform bodies on the posterior part of the oblong process.

The continuation of these bodies into the spinal cord, and their descent in it, are obvious. No authorities, therefore, need be adduced from the observation of others upon this point.

Hence I stated, that, "from the cerebellum, it [the medullary matter, or cerebral bundles] passes downward by the corpora restiformia [restiform bodies], superior fasciculi of the medulla [oblong process], processus cerebelli ad medullam or posterior peduncles of the cerebellum, to the posterior columns of the spinal marrow, and the remaining portions of the numerous nerves which join it. Thus the medullary fibres form a

* Nun dringen die hinteren Schenkel mit dem vörderen Rand ihres Stamms zwischen den vörderen und seitlichen Schenkeln durch, legen sich als inneres, etwas vorsprengendes Blatt an die seitlichen Schenkel an, und beide werfen sich nun gemeinschaftlich als Wulst über die vörderen Schenkel und das zwischen ihnen liegende vördere Marksegel hin, und vereinigen sich im Wurm.—*Lib. cit. p.* 497.

most remarkable circle of which this is the direct course."

That the posterior columns and roots are evidently prolongations of the cerebel, which so many observations, recorded in the preceding section, prove to be the organ of volition and to control the motions of the body, is an evident indication of their functions, as connected with voluntary motion. The reader should refer to those observations, if they be not borne in mind.

In regard to the nerves arising from these parts, it should be noticed, that it is entirely from posterior parts that motive nerves arise; those having much to do with involuntary motion, like the general oculo-muscular, internal oculo-muscular, and trifacial, or 3d, 4th and 5th arising between the brain and cerebel, and those which are chiefly voluntary, like the external oculo-muscular and facial, or 6th and 7th, arising below the cerebel. But every one of them distinctly passes over or through the anterior, ascending, or sensitive parts.

That the posterior roots of the spinal nerves are by much the largest, is also in perfect harmony with the relative size of anterior and posterior, or ascending and descending, parts throughout the nervous system, as already pointed out.

As to the respective periods of the growth or completion of ascending and descending parts,

so much has been said when speaking of the former, that little more need be added now.

Tiedemann observes, that "in the third month these bundles, thus rising from the spinal cord [that is posteriorly] have acquired remarkable thickness . . . uniting, they form the small bridge-like cerebel extended over the fourth ventricle."*—In the fourth month, the motions of the foetus are felt. The canal of the spinal cord is obliterated soon after.

Here we see the remarkable coincidence, which was formerly mentioned as to the completion of posterior or descending parts, and the appearance of muscular motion.

It is not, however, only in the young of the human species, that this coincidence is found.—Serres states that the canal of the spinal cord is found in the larvæ of frogs, until the anterior and posterior limbs appear.

He further states, that even the enlargement of the spinal cord in the embrios of man, mammalia, birds and reptiles coincide in time of appearance with the appearance of limbs, just as is the case with frogs at the period of metamorphosis from the larva to the perfect animal; and

* Im dritten Monat hatten die aus dem Rückenmarke sich erhebenden Stränge an Dicke merklich zugenommen... Unter sich verbunden, das schmale über die vierte Hirnhöhle brückenartig gespannte kleine Hirn bildeten.—*Lib. cit.* *p.* 102.

those animals which have only a pair of limbs as the cetacea have only one enlargement.

That, on the posterior bundles of the oblong process, as the continuation of the inferior peduncles of the cerebel, muscular motion depends, is proved even by Magendie's experiment in which the division of one or both the pyramidal bodies produced no further effect than a slight impediment in moving forward, whereas a division of the entire half of the oblong process produced palsy of the same side of the body—depending doubtless on the division not only of the restiform bodies, on which as descending from the cerebel, voluntary motion depends, but on that of the olivary bundles, on which, as will afterwards be shown, involuntary motion depends.

That, as Magendie states, the division of the posterior pyramids, or restiform bodies, produces no visible alteration of the general movements; and that to obtain the paralysis of one half of the body, it is necessary to cut through one half the oblong process, is evidently because thus alone both the voluntary and involuntary bundles are cut across.—If even then, as he says, the corresponding side becomes not immovable, for it presents several irregular motions; nor insensible, for the animal moves its members when we pinch it; that is plainly owing to a cause already before the reader, by which involuntary actions are maintained through

the ganglia or commissures of the spinal cord and nerves.

There can, I believe, be no clearer vindication of the accuracy with which I stated, in 1809, that "from the cerebellum, it [cerebral action] descends through the posterior columns of the spinal marrow, which are, therefore, its descending columns; and expands through the posterior fasciculi of all the nerves, which are therefore the nerves of volition, and the connexions of which with the spinal marrow or brain must be termed their spinal or cerebellic origins. This precisely is the course of its descent from the sensorium commune toward the muscular system."*

* The following case is related by C. F. Bellingeri, principal surgeon to the hospital San Giovanni.

A girl, thirteen years of age, of delicate constitution, affected with a wen on the side of the neck, but in other respects in perfect health, was seized suddenly, without shivering, with pain on the left shoulder, and region of the larynx, rigidity of the neck, also severe pungent pain in the region of the occiput, and difficulty of opening the mouth. Though she experienced torture on deglutition, she got up, and was able to eat. Next morning, she felt pricking pains along the dorsal vertebræ, accompanied by a sensation of twitchings of the inferior extremities, though she walked about. On the third day, the same symptoms continued; the rigidity of the neck became so bad that she was obliged to go to bed. On the fourth day, stiffening of the limbs commenced; they were drawn backwards; and next morning, the head and neck became similarly affected.

Thus the doctrine delivered in this Chapter involves not only the roots of the nerves of one

Three or four days after this, M. Bellingeri examined her for the first time.

The head and neck were now drawn backward; the head slightly inclined to the right side; and the curved spine forming its convexity anteriorly. *The legs and thighs were also drawn backward,* and were capable of being bent only by external force, which caused great pain. *The movements of the superior limbs were stiff;* the fore-arm being less motionless than the arm; all flexion appeared lost, so that it could not be raised to the head: the attempt to bend either arm or fore-arm gave excessive pain. The pupils were constantly contracted, and thus remained, when a lighted candle was placed close to them or at a distance. Neither sight nor hearing was affected, with the exception of a slight buzzing noise, of which she complained, annoying her every now and then. The alæ of the nose were drawn upwards, and remained in an arched position: the upper lip was also raised, and she was unable to approach one lip to the other. The commissures of the mouth were slightly retracted, and gave her a kind of sardonic smile. In fact, all the muscles of the face were contracted; and the cheeks hollowed, which gave her a cadaverous aspect. *Sensation all over the body was perfect.* There was great difficulty in moving the inferior jaw; and she was unable to protrude the tongue farther than the alveolar arch. There was a certain degree of dysphagia; and she could only swallow spoonfuls of liquid. The pulse was small and contracted, 104. The abdomen was tense and flat. In attempting to administer an injection per anum, much resistance was offered by the sphincter. The discharge of urine was voluntary. The heat was little greater than natural; and there was a slight and continued moisture of skin. She com-

column of the spinal cord, but those of both,—the columns themselves,—the progress of the

plained of constriction of the throat, for which the jugular vein was opened. The spasms disappeared for a short time, and returned with greater severity, so that death appeared to have been produced from asphyxia, owing to a spasmodic closing of the glottis. Immediately after death, the left arm was drawn spontaneously backward.

Twelve hours after the body was cold, the limbs remained in a state of stiffness; and in twenty-four hours, flexibility returned.

On the posterior surface of the spinal cord, was found a simple sanguine extravasation without congestion, which occupied the external surface of the external membrane from the third to the sixth dorsal vertebra. On cutting through the external membrane, the arterial vessels of the internal membrane, where it lined the posterior part of the medullary substance, were more or less congested, from the ninth dorsal vertebra to the inferior part of the spinal cord. This existed throughout the whole extent of the posterior surface; but it was very extensive at its superior extremity and at its origin. *In all these regions, it is necessary to notice, that the engorgement was limited by the posterior origin of the nerves on each side, and did not extend on the lateral surfaces of the spinal cord.*

On the anterior face of the spinal cord, the cellular tissue which lined the external membrane, as well as the membrane itself, was, throughout its extent, much injected,—much more even than its posterior surface. This membrane being opened, the middle spinal artery was found much engorged with arterial blood: so also were some of its ramifications, particularly those in the lumbar region.

The spinal marrow itself was healthful.

In the head, there was slight sanguine extravasation between the external and internal membrane. The superior

anterior through the brain,—their return through the cerebel,—their descent to join their poste-

part of the brain was much injected with red blood, though limited to the arterial capillaries of the internal membrane. *That portion of the internal membrane lining the cerebel and cerebellic ring was also much gorged with red blood, as was also the inferior extremity of the oblong process.*

The brain was in a normal state.

The following are the deductions drawn by Bellingeri from these facts.

The anterior surface of the cerebellic ring is formed of fibres coming from the cerebel: irritation of these fibres is capable of producing spasms in the direction of extension, principally of the head and neck; and it also causes trismus, spasmodic dysphagia, and constriction of the pharynx.

The posterior part of the spinal cord presides over extension: in fact, we observe its injection produce this effect; slightly, however, in the superior limbs, the injection being less intense in the cervical region; stronger in the inferior, for another reason. Injection of the internal membrane of the cerebel also demonstrates that this organ governs the movements of extension.

The injection in this case was limited to the pia-mater, and the symptoms were confined to muscular contractions. This proves that irritation limited to the white substance of the spinal cord produced spasm only, without altering the sensibility; and that the posterior roots of the nerves of the spinal cord, are not destined for sensation, since the inflammation, by which they were affected, produced neither augmentation nor diminution of the general sensibility. Lastly, the inclination of the head to the right side appeared owing to the slight engorgement of the middle lobe of the right hemisphere of the brain.

In a second case, the subject was a young man, who was

rior,--and their completion of the chain of nervous circulation,—a circulation as much more important than that of the blood, as the intellectual is more important than the vascular system.

As connected with the last Section, I may here mention the posterior pyramids, though I know not their superior connexions, and consequently can enter into no reasoning respecting them.

Rolando, who has well described them,* says

attacked with lumbar pains, and permanent spasms of the flexor muscles of the trunk, but more particularly of the inferior extremities. M. Bellingeri stated this disease to be a chronic inflammation of the spinal cord. The sentient system remained perfect. Under the antiphlogistic treatment, the patient recovered.

* Les bords de la partie inférieure du 4e ventricule sont formés par deux éminences composées de fibres médullaires, plus visibles que celles dont sont composés les pédoncules inférieurs du cervelet. On a donné le nom de pyramides postérieures à ces éminences.—Je crois qu'on a donné à ces éminences le nom de pyramides postérieures, parceque, de l'endroit où le nerf acoustique traverse les pédoncules inférieurs du cervelet, elles commencent par une pointe très mince. En descendant elles grossissent, et forment une espèce de massue; et à mesure qu'elles s'approchent et se touchent ensuite sur la ligne médiane, elles forment le bec de la plume à écrire. De cet endroit, ces fascicules, insen; siblement aplatis, et sous forme de lames assez minces, descendent entre les deux cordons postérieurs de la moelle épinière, jusqu'à la hauteur de la septième paire des nerfs

that these cords of the oblong process go to the middle and superior region of the cerebel. Reil observes that the grey substance of the lozenge resembles that of the tubercles and posterior striated bodies, being paler and firmer than that of the anterior striated body, and disposed in fibres, which run parallel with its median furrow, the pen. Mr. Mayo regards the posterior pyramid as terminating in the longitudinal fibrils of light grey matter which thus form the floor of the 4th ventricle.

cervicaux à peu pres. Au premier aspect il paraît que ces corps ne sont que des éminences qui s'elèvent des pédoncules inférieurs du cervelet, mais, par le moyen des coupes transversales, on peut voir qu'ils sont deux petits cordons cylindriques bien distincts, souvent isolés et formés par des fibres médullaires tordues.—*Recherches Anatomiques.*

CHAPTER III.

STRUCTURE AND FUNCTIONS OF THE SENSORIAL EXPANSIONS.

THESE expansions have not hitherto been viewed in connexion. They are five in each hemisphere.

The central one extends, as they all do, from the anterior to the posterior part of the brain, traversing the anterior, middle, and posterior lobe; it includes, of course, both white fibrous matter and convolutions; it more immediately envelopes the lateral ventricles; and it forms a basis for the other expansions. On it, are formed superiorly the two convolutions which run along the inner and upper margin of the hemispheres. Two of the other expansions are placed mesially; and two laterally, to the central one. As together they correspond in number to the organs of sense, and have relations to them which will be afterwards mentioned, I have termed them sensorial expansions.

The lateral and mesial expansions have been noticed little, if at all, in this country. Yet they are of great magnitude, and doubtless of great importance. Each hemisphere has con-

sequently been regarded as one mass, undivided in the longitudinal direction.

I think it probable that the 9th, 11th, 22d, and 26th plates of Vicq d'Azyr, in which sections of one or both of the lateral expansions are seen, first called the attention of anatomists to these parts; and, as already said, there are many other things in these sections that would repay inquiry.

Abandoning his own method, Reil was induced to describe some portion of the lateral expansions as the external wall of his capsule of the anterior striated body, which he considers as having three surfaces; an outer and an inner wall, and a floor. The floor he regards as made up of various parts; the inner wall, as formed by the outer surface of the fibrous cone; and the outer wall, as composed of a portion of what he terms the hamular bundles. The substance contained in this capsule is the outer portion of the anterior striated body, the inner part of which projects uncovered into the lateral ventricle. The hamular bundles which seem properly to be the particular base from which the lateral expansions ascend, he describes as passing from the inner and under convolutions of the anterior lobe, near the root of the olfactory nerve, and thence extending across the fissure to the projection forward of the middle lobe;

their outer extremity blending closely with the fan-like expansion of the anterior commissure.

Reil also well describes the external parts contiguous to the lateral expansions.—He observes that the fissure of Sylvius extends, from its commencement below, obliquely upwards and backwards for more than a third of the length of the brain; that the boundary of the fissure belonging to the anterior lobe may be termed its roof, and that belonging to the middle lobe its floor, which meet behind at an acute angle; that intermediately they inclose a space, covered with low convolutions, which are surrounded by a gutter-like depression; and that these low convolutions, which form the island, are placed upon the hamular bundles.

It is to Rolando, however, that we are chiefly indebted for an account of the two lateral expansions, to which a considerable part of his Paper "Della Struttura degli Emisferi Cerebrali," is devoted.

In considering, then, the lateral expansions more systematically, I may observe that the inferior anterior point from which the convolutions of the island radiate, covers what Rolando calls the antero-median, or olfactory arch, the hook-like bundles of Reil, of which the fibres extend, by means of their curve adapted to the bottom of the fissure of Sylvius, both to the anterior and the middle lobe; and its widely

extending posterior extremities form the convolutions on the posterior and inferior surface of the latter of these.

Rolando terms this the olfactory arch, because its fibres, as he says, seem to go directly to the olfactory nerve, and they form, he asserts, a great part of the convolutions which we see in the orbital or inferior region of the anterior lobe. He has not, however, shown clearly the former of these circumstances; and it is not improbable that the vicinity of the external termination of the olfactory nerve may have misled him in that respect.

This arch is in contact with the optic tracks, the perforated plate, the anterior commissure, and the nucleus of the external portion of the striated body.

There insensibly radiate upward from this arch two white plates or layers, separated in the middle by a thin layer of brown substance. These are the external plate of the valley of Sylvius, and the internal plate of the vertical convolutions, or the beginnings of the external and internal lateral expansions.

We may first describe the external lateral expansion.

The most external fibres which rise from the arch, in proportion as they separate from the plate to which they belong, lose themselves in the radiated convolutions of the island. Joining

its periphery, they bend outward on themselves all around the valley, and finish in the internal part of the extensive convolutions surrounding it.

By its internal surface, this plate is in contact with the interposed thin layer of brown substance, and where that disappears, with the external surface of the plate of the vertical convolutions, with the external fibres of which it concurs in forming the convolutions alluded to.

On the side of the brain, then, and in the somewhat triangular aperture of the fossa of Sylvius, may be observed the small convolutions which constitute the island, and which are formed on the radiation of this plate.

When the sides of the fossa are separated, these convolutions appear to be five in number, but subdividing so as to make seven, eight, or nine, and they appear to radiate from a point at their inferior anterior part, their general direction, however, being upward. Collectively, they form a somewhat triangular eminence of which the base is turned upward.

The convolutions of the island are bent outward and continued into the margins of the fissure, so that these present a triangular arrangement, corresponding to that of the island which they close upon and cover.

The white plate, then, which is under these, not only forms the island, but the sides of the processes of the anterior and middle lobe by

which it is surrounded, and of which the long upper and under sides are the most remarkable.

The convolutions surrounding the island, appear first in the fœtus, though slightly, during the second month.

We may next describe the internal lateral expansion.

From the olfactory arch, in the same manner, rises the white plate of the vertical processes and their appendices. Its fibres run parallel to those of the arch both in the anterior and middle lobe, but the greater number expand like a fan over a great portion of the hemisphere. Hence the most external concur in forming the convolution surrounding the valley of Sylvius; the anterior go to the lower part of the frontal lobe, and contribute to form the convolutions which receive the olfactory nerve; the middle ones lose themselves in the vertical convolutions and their appendices which form anteriorly the circular convolutions; while the posterior disappear in the convolutions of the occipital region.

These fibres, disposed in fine plates, cover all the external and lateral face of the hemisphere; but they do not reach the two convolutions which run along the inner and superior margin of the hemisphere and which proceed from the middle fibres of the peduncles, or the central expansion: on the contrary, they form only in part those convolutions which turn, one forward,

the other backward, from the two middle vertical ones.

Externally, this layer is covered by the external one and by the intermediate layer of brown substance. By its internal surface, it is in connexion with the anterior commissure, the external striated body and the fibres of the peduncles, with which it unites so intimately that they seem to form a decussation. Yet all around the striated body, the fibres of the peduncles turn a little over the layer of the vertical convolutions.

The system of convolutions formed by this layer, is of greater magnitude than the last. They are generally four in number. They come, by their lower extremities, into contact with the upper boundary of the fossa of Sylvius. They ascend somewhat vertically (hence Rolando calls them vertical convolutions) but with some inclination backward; the anterior two extending and ramifying forward, and the posterior two extending backward; so that they form nearly the whole side of the brain above the fossa of Sylvius. They do not, however, form much of the middle lobe which runs forward under that fossa, nor of the posterior which is behind it, nor even of the upper convolutions running along the longitudinal fissure, nor of the anterior, and anterior inferior ones.

On the removal of the layer of the fissure of

Sylvius and some plates of the layer of the vertical convolutions, are seen the brown external striated body, and part of the anterior commissure, while the olfactory arch is also further exposed.

With regard to the mesial expansions, when a longitudinal section is made of the brain along the median line and it is divided into two lateral halves of which one is viewed internally, the convolutions over and around the great commissure have an arrangement somewhat corresponding to that of the external side.

We may first describe the outer mesial expansion.*

One convolution, the crested one of Rolando, which begins from the internal root of the olfactory nerve, runs close to and around the commissure, passes on the inner surface of the middle lobe, and terminates in the convolution that covers the great bend in that lobe, or more particularly in its hook.†

* Outer and inner, with regard to these two expansions, are now used in relation only to the separated hemisphere, and its central expansion, so that in this respect the most mesial is the outer.

† This convolution was described by the Wenzels as follows: — Interiori in facie utriusque hemisphaerii cerebri, proxime corpus callosum, invenitur quidem gyrus, respectu figurae, longitudinis, latitudinis atque decursus sui utrimque sibi similis pene symmetricus, sed et hi ambo saepe multum inter se differunt.—*De Penitiori Structura Cerebri*, p. 23.

By scraping the brown substance which forms the exposed side of the crested process, we discover a bundle of white fibres having the same direction. Attentive examination shows that they are continued from the internal root of the olfactory nerve, where that passes into the great fissure and forms the anterior extremity of the crested process.* Thence this bundle ascends by the anterior lobe and around the turn of the great commissure: its fibres increase, and if at first they form a bundle of the thickness of a crows' quill, when joined to the commissure they become as thick as a common pen and of somewhat triangular form. Preserving the same thickness, they advance to the posterior extremity of the commissure around which they turn to form the convolution which Vicq d'Azyr says contains the greater bend, and reaching the hook, they resolve themselves into white fibres which go to the apex or most internal convolution of the middle lobe.

This white bundle perpetually sends off numerous fibres, which, from its superior side, expand like a crest which rises all around the commissure.

* Esaminando attentamente questo fascicolo de fibre si può vedere che esse si continuano colla radice interna del nervo olfattorio, ove questa s'introduce nella grande scissura, e forma l'estremità anteriore del processo cristato.—*Della Struttura degli Emisferi Cerebrali, p.* 26.

We may next describe the inner mesial expansion.

The fibres of the bundle which forms the crested process are not, however, in contact with the upper surface of the superior commissure, but between these is found a layer of fine transverse fibres, which forming a slight elevation by the sides of the median line of the commissure, produce those longitudinal lines, which Reil has described, and these leaving a linear depression between them cause the arrangement which has been called the raphe.

From the margin of these striæ of Reil, are directed forward white fibres, which pass between those fibres of the commissure which go to the posterior striated bodies and the bundle of the crested convolution. Hence bending upwards at a right angle, they leave the fibres of the posterior striated bodies which descend, whilst these run between the fibres of the crested convolution and those of the peduncles, to diffuse themselves in the convolutions above the crested convolution, and extend to the upper margin of the hemispheres.

The parts last described are termed by Reil the covered bands [bedeckten bänder], and he describes them as situated on either side of the raphe, within the two convolutions, which are in immediate contact with the great commissure. —In his detailed and minute account, he ob-

serves, that parallel with, and on either side of the superior raphe, may be found a flattened white bundle which, lying concealed by the convolution in contact with the upper surface of the superior commissure, is termed the covered band; that this convolution may be traced from the fore and lower part of the anterior lobe, where it is reflected forward from the convolution touching the root of the olfactory nerve; that this convolution thence advances forward and lies over the anterior fold of the commissure, then continues along its upper surface in a line unbroken, except towards the posterior fold by some vertical indentings, and finally sweeps downward and forward again, and skirts the aperture of the inferior horn; that either posterior pillar of the arch, which is at first composed of white substance alone, derives from this extended convolution a supply of gray matter, which is contained in its navicular cavity, thus forming the greater bend; that, when this convolution is turned aside, the covered band is seen;—that this band terminates anteriorly at the meeting of the fillets of the perforated plate with the anterior fold of the commissure, becoming more delicate as it approaches this point, and finally fibrous and reciprocally continuous;—that it turns round the anterior fold of the superior commissure, extends to the anterior commissure, and brings away with it, when

raised, all the convolutions which belong to the inner and central part of the anterior lobe; that it may easily be raised from its adhesion to the superior commissure, the fibres of the latter externally to it losing their former fasciculation, and being arranged in delicate plates, more closely attached to each other; that in like manner it turns round the posterior fold, becomes continuous with the posterior pillar of the arch and the long convolution above described; that turning round the posterior fold within the long convolution, it gives off one delicate radiation, which joins and is interwoven with that derived from the posterior fold to the floor of the posterior and inferior horns, its larger portion becoming continuous with the white matter of the extremity of the long convolution now employed in the formation of the greater bend; and that thus on either side, the covered band forms a circle round the root of the hemisphere, unbroken except at the entrance of the fissure between the anterior and middle lobes.

Thus these two series of convolutions are confined to the middle of the inner side; and, precisely as on the outer side, the convolutions around these—before, above, behind, below, belong a different system, namely that of the peduncles.

Thus the radiation from the peduncles, the central expansion, lies between that of the

vertical convolutions without and that of the longitudinal fillets within.

With regard to the intersection of the fibres of these parts, it should be observed, that, as mesially to the fibres from the peduncles is found the layer of the great commissure, those fibres which are derived from the main portion of the commissure meet, as observed by Reil, at an acute angle, and sometimes directly anastomose with the middle bundles of the fibrous cone, and also with those derived from the inner and outer walls of his capsule; and that, at the upper margin of the outer part of the striated body, the outer and inner walls of the capsule itself meet at an acute angle, decussate each other, and are interwoven; or, as stated by Rolando, that around the margins of the striated bodies, the incurvated fibres of the peduncles interlace in such a manner with those of the plate of the external layer, that it would appear that some of these go to the convolutions of the peduncles, and small bundles from the latter descend into the inferior convolutions of the external layer. Thus are these expansions connected.

With regard to the external aspect of the convolutions presented by these parts, those immediately covering the five expansions have been already described; and it is only necessary further to add that the convolutions of the

frontal region are very irregular, because these unite fibres from the external layer, those of the peduncles, and others from the inner surface of the hemispheres; that among the most regular are those divided by the furrow receiving the olfactory nerve, which Rolando says, are formed by fibres from the layer of the vertical convolutions which lose themselves in the inferior surface of the anterior lobes, and by fibres from the crested arch; that the convolutions of the posterior lobe seem also irregular, more especially as they join those belonging to the anterior commissure in the intermediary convolutions of the middle lobe; and that the two convolutions running longitudinally at the top of each hemisphere are anteriorly and posteriorly confounded with the vertical convolutions.

The functions of the five sensorial expansions are at present no further determined than that they appear to be connected with the five senses respectively.

The large central expansion is more especially the cerebral organ of the most diffused sense, that of touch. This is proved by the fact, that the anterior or ascending bundles of the spinal nerves, spinal cord, oblong process, and cerebral peduncles, through which alone the sense of touch can ascend, are demonstrably diffused in and compose this expansion.

Hence Rolando who did not perceive the general relation of these expansions to the senses, nor that of this in particular to the organ of touch, yet calls this central expansion "lo strato de' pedoncoli degli emisferi."

This fact as to the composition and general function of the central expansion, is of much importance; for, as this great expansion forms a basis for the rest, as observed at the beginning of this chapter, so does the sense with which it is peculiarly connected form the basis of all other sensation, as was shown in the chapters on that subject; and on observing this analogy, we are naturally led to suspect that the remaining expansions may be respectively connected with the other senses.

This receives a strong confirmation when, on proceeding to another expansion, the external medial, we find that it directly receives the internal root of the olfactory nerve—"esaminando attentamente questo fascicolo de fibre," says Rolando, "si può vedere che esse si continuano colla radice interna del nervo olfattorio." Hence also we may conclude that, as the central expansion is more especially the cerebral organ of touch, so this external mesial one is the cerebral organ of smell. This new case, moreover, gives additional probability to the still remaining expansions being respectively connected with the other senses.

The internal mesial expansion has apparently a similar relation to the internal termination of the optic nerve. This ascends from the optic commissure, as a medullary plate in front of the third ventricle, and is continuous with the perforated plate or lamina cribrosa of Meckel: it is pointed out even by Vicq d'Azyr as a termination of the optic nerve. Reil accordingly observes that "a thin layer of nervous matter is continued from the furrow and posterior margins of the fillets (of the lamina cribrosa) to the commissure of the optic nerves, closing the third ventricle," and he observes also what is here of more importance that "pure white fibres sometimes proceed from them (the fillets of the lamina cribrosa), which mostly plunge into the blind hole, and lose themselves in the thin partition, but sometimes also ascend along the outer part of the anterior fold, bend around the anterior part of the great commissure, and join its upper surface with the line of Lancisius."* It is remarkable that this termination of the optic nerve bears the same relation to it that the

* Von denselben gehn zuweilen hellweisse Fäden ab, die meistens in das blinde Loch über dem Schnabel eindringen und sich in die Scheidewand verlieren, zuweilen aber auch auswendig auf dem Schnabel fortgehn, sich um den vörderen Theil des Balkens herumkrümmen, und auf dessen oberen Fläcke mit der linea Lancisii zusammenfallen.—*Archiv für die Physiologie, Eilfter Band*, p. 348.

similar termination of the olfactory bears to that nerve. Thus the internal mesial expansion may similarly be the cerebral organ of seeing.

Of the external lateral expansion, I can only say that from its close connexion with the lower part of the middle, or more properly with the inferior lobe, which I shall show to belong to the vital system, from its external relations to the jaw and the muscles of mastication (for, as already said, cerebral organs and the external parts which they influence approximate in position), and from analogy with the preceding expansions, I am disposed to think it the cerebral organ of taste.

As to the internal lateral expansion, the data are fewer still. I know indeed of none but its external relation to the ear, and the empirical fact, if a fact it be, asserted by the craniologists, that an enlargement of the scull immediately over the anterior part of this expansion is connected with the perceptions of sound.

Finally, I may observe that the correspondence of the number of these expansions to the number of the external senses, the analogy of their situations to those of the senses respectively, and the distinct termination of nerves from the corresponding senses in several of them, render it probable that similar terminations take place in the remaining expansions, that the whole are

the cerebral organs of the senses, and that they may properly be termed sensorial expansions.

That the nerves of taste and hearing are not so easily traced to the lateral expansions as those of smell and seeing to the mesial ones, is easily accounted for from the nerves of the former senses being earlier confounded with the other ascending bundles; and this, as explaining the cause of difference in this respect, tends to confirm the view now taken.

The utility of a distinct cerebral expansion for each sense will be obvious, when we consider that the pictures transmitted by vision (for the image on the retina proves them to be so) could scarcely repose in the same locality with the vibrations of hearing, which the organization of the ear shows, are transmitted to the brain.

It is at the same time certain that other terminations of the nerves of seeing and smell have connexions with the four tubercles, and probably with the middle parts of the brain in general; and it is not less certain that other terminations of the nerves of hearing and taste have connexions with the cerebel, and probably with the posterior parts of the brain in general. The nerves of the special senses were formerly considered as having fewer terminations than recent observations prove them to have.

CHAPTER IV.

STRUCTURE AND FUNCTIONS OF THE SUPER-ADDED PARTS.

SECTION I.

ENUMERATION OF THESE PARTS.

At seven weeks, says Tiedemann, "I perceived no traces of the other parts of the brain, namely, of the pons varolii [transverse ring], commissures, corpus callosum [superior commissure], or fornix [arch] or its appendages."*—Again he says at nine weeks, "the other parts of the brain, as the transverse ring, great commissure, arch, greater bend, commissures, &c. were not in existence."†

When to this we add the fact, that the con-

* Von allen übrigen Theilen des Hirns, namentlich vom Hirnknoten, von den Commissuren, von dem Balken, von dem Bogen and seinen Theilen habe ich keine Spur gefunden.—*Anatomie und Bildungsgeschichte des Gehirns, p.* 14.

† Die übrigen Hirntheile, der Hirnknoten, der Balken, der Bogen, die Ammonshörner, die Commissuren u. s. w. waren noch nicht vorhanden.—*Ibid. p.* 16.

volutions and interconvolutional bundles, the superior commissure, the cerebral ventricles in their extended and perfect state, the cerebral arch, the cerebellic or transverse ring are found in no animals below mammalia, the reason for here calling them superadded parts will be evident.

In mammalia, the convolutions, the superior commissure, the arch, the transverse ring, &c. are found.

These, be it observed, are the parts, which though only next in importance to the original and fundamental ones already described, are yet *of higher character*, as will be seen by the functions here ascribed to them.

SECTION II.

STRUCTURE AND FUNCTION OF THE CONVOLUTIONS—THE ORGAN OF MEMORY.

The last chapter contained a brief view of the parts which are covered by the convolutions; and it will be seen that this chapter properly begins with a more particular account of them, as the first of the superadded parts. Of these parts, they are truly the first; for they are formed on the highest radiations of the ascending masses, and may be considered as preceding the descending ones both in place and in function.

In the mouse, rat, marmot, beaver, bat, &c. the hemispheres do not present convolutions,

nor extend over the tubercles, precisely as in the fœtus at the third month.

In the Carnivora, Ruminantia, &c., they have convolutions, and cover not only the tubercles but part of the cerebel, as in the fœtus at the sixth and seventh month.

In monkies, the convolutions are fewer and more regular than in man; and the division into anterior, middle and posterior lobes is more obvious.* These animals first present a third or posterior lobe, the imperfection of which is, however, marked by the absence of convolutions, except in the chimpansee (simia troglodites) and gibbon (simia lar), nearly as they there appear at the latest period only of the existence of the human fœtus.

As we descend, on the contrary, among mammalia, the convolutions of the brain disappear before those of the cerebel; the hare, rabbit, squirrel, mole and wall-rat being examples of this. This agrees with the degeneration of the organ of intellect in animals in whom the organ of voluntary motion is still large and active.†

* Numerus gyrorum et sulcorum cerebri simiarum multo minor est quam in homine. Phocae et delphini encephalus numero gyrorum et sulcorum illum simiarum superat, eique hominis proxime accidit.—*Tiedemann—Icones Cerebri Simiarum, p.* 49.

† Hinc statui posse nobis videtur in animalibus, saltem in

Of the structure of the convolutions and the double radiation of the fibres of the peduncles of the brain, Tiedemann says that the latter proceed upward, forward, and backward, and bending inward, form the roof of the lateral ventricle, and then approaching those of the opposite side, unite together, and form the superior commissure, thus composed of transverse fibres; that, on these fibres, others are applied, which, radiating from the centre to the circumference, pass into the convolutions; that this is effected by new fibrous layers deposited on the external surface of those previously formed; and that he perceived this second order of fibres each time that he tore a portion of a brain which had remained some time in alcohol, whether the rupture were longitudinal or transverse.

Tiedemann is also quoted by Rolando as observing that, in the fœtus of from three to four months, a fine pile appears to spring up which forms a downy layer; that the extremity of

iis, quorum cerebrum disquisitioni subjecimus, gyros in cerebello inveniri, quorum nulla in cerebro vestigia sunt.

Conjecturam inde facere licet, inter functiones cerebelli, quae ex constitutione superficiei ejusdem pendent, unam, forsan etiam plures esse, quae examinatis a nobis mammalibus, vel omnibus communes sint, contra vero in functionibus cerebro convenientibus unam aut aliquas esse, quae multis tantummodo mammalibus peculiares, non omnibus communes sint.—*Wenzel—De Penitiori Structura Cerebri, p.* 24.

this pile is of a different nature from the medullary fibres, and is the first rudiment of the brown substance; and that about the fifth month it has acquired a line and half in length, and its communication may be seen with the parallel fibres which form the white plates from which this pile rises at an angle more or less obtuse.

If the convolutions and their separations of one side or hemisphere of the human brain be compared with those of the other, a considerable difference is found in their figure, direction, connexion, situation, length, and breadth. The convolutions, however, are less variable in the base of the brain (that is, where they belong to the vital system), but more varied above (that is, where they belong to the intellectual system).

The general arrangement of the convolutions was described in the last chapter, which may be referred to for connexion with the present in that respect.

The largest convolutions are those of the parietal and temporal regions, and the smaller those of the frontal and occipital. The most elevated convolutions are those in the vicinity of the fissure of Sylvius, and the least elevated, those of the island.

The convolutions are formed of a layer of grey matter, containing white which consists partly of the diverging, converging, and commissural fibres, and partly of fibres parallel to

the surface, which may be regarded as constituting a distinct organ.

It seems at first evident that, in the convolutions thus superimposed, terminal, and affording a vastly extended surface, traces of action ascending thither, and thence descending, must be left. It is indeed even difficult to see what other purpose such superposition can serve. I accordingly suggested in 1809, that they constituted the organ of memory.

On repeating this to Dr. Spurzheim, in 1814, as accounting for a few of his organs which seemed to me to furnish indications to be somewhat relied on, he observed that a German physiologist, Mayer, of Frankfort-on-the-Oder, had recently expressed that opinion; and, on my showing him the passages* which I had published on the subject five years before, he seemed pleased with the coincidence, and with this approach to a reasoned ground for some of his conclusions. He also subsequently mentioned to me his having suggested my opinion to Sir Everard Home, who subsequently adopted it.

I may now assign the reasons which appear to me to render it at least highly probable that memory is the function of the radiation in the hemispheres and more especially of their termi-

* Archives, Vol. 2, p. 203, &c. April, 1809.

nations in the convolutions, for it seems obvious that the extended termination in the convolutions is the great purpose of the previous radiation.

In the first place, as memory depends on previous impressions and their permanence, it is evident that its place or organ in the brain cannot be one in which such impressions would be perpetually disturbed by the passage through it of the actions contributing to other functions: it must be terminal, if I may use that word.

Now, in the whole brain, there is not any locality of this description but the bases of the convolutions. The vast radiations of the hemispheres and their ascending motions terminate there; and the former seem to exist chiefly for the purpose of so terminating. All the converging and commissural fibres return from the same surface. The convolutions are terminally superimposed upon the union of these diverging and converging fibres. Here, then, and here alone, is to be found the first organic condition which memory requires.

In the second place, impressions require an extended surface. In the eye, accordingly, we find that, even for the single and transient impressions of vision, the optic nerve is expanded into the retina. But for the purpose of memory, whose impressions are manifold, it is evident that a far greater expansion is necessary—even

though peculiar impressions may tend to ascend through appropriate fibres, and though similar classes of impressions may be grouped in similar localities—a circumstance which seems necessary to the recalling of past impressions.

Now, in the whole brain there is no surface which has any expansion at all comparable to that of the bases of the convolutions. As some of the convolutions are an inch in depth and as they are spread all over the surface of the brain —below, laterally, above, before, behind, and between its hemispheres, as subordinate convolutions are even found overlapped by superficial ones, it is evident that their surface, if uniformly extended, would be of great magnitude indeed, and that some fibres in the narrowest part of the upward ascent, have, resting upon them, cones of which the bases in the convolutions have perhaps a thousand times their original extent. Here, then, and here alone, is to be found the other great organic condition which memory requires.

When, therefore, I contemplate the respective magnitude of the organ and function in question, and the adaptation to the latter which the former presents, I cannot help concluding, even from these circumstances, that the cerebral convolutions are the organ of memory.

In support of these views, I may now further observe, that it has been repeatedly noticed

by physiologists, that, after injuries of the head, eventually followed by idiotcy, failure of memory was the first mental symptom observed.

I attach little importance to the opinion of Sir E. Home, which is a recent modification of my own, namely that the *brown* substance is the seat of memory; but it is not here irrelevant. He states himself to have observed that "that faculty is destroyed or materially diminished by any undue pressure upon the upper anterior part of the brain, as in that requiring the operation of the trepan; while, in hydrocephalus, where the liquid is in large quantity, and there remain only the brown substance of the brain and the transverse ring, the memory can retain passages of poetry," &c.

It appears, however, that when the mental processes are feeble, they leave no trace in the organ of memory.

Memory appears to be only a more or less accurate repetition of former intellectual operations re-induced by succeeding ones, and it will, consequently, be more or less perfect according as intermediate operations may have been of the same or of a different kind.

Between memory and recollection the distinction is, that memory is an involuntary operation; recollection, a voluntary one. Conception, as employed by Mr. Stewart, appears to me to belong to memory.

As to the mode in which these traces are left, an old anatomist says—"Non opus est, et non contendimus hic, illa vestigia debere esse similia rebus significatis; sic quando scribo Deus, quid quæso commune est inter has litteras, earumque certas delineationes, et inter cogitationem, quæ Dei essentiam constituit? nil sane communionis intercedit, inter hanc delineationem factam atramento in chartâ albâ; voluit Deus nectere tales cogitationes, cum illis impressionibus et radiationibus, et sufficit nobis, si modo assueverimus nectere nostras cogitationes, cum illa figura, cerebro impressa. Sic cum videmus illas litteras Deus, statim oritur in nobis cogitatio substantiæ cogitantis et incorporeæ, et sic de omnibus rebus est cogitandum, de quibus cogitamus, quatenus assuevimus hoc, cum tale vestigium tantum est cerebro impressum, tunc statim rem illam nobis imaginamur, facta prius radiatione spirituum certa ab illo vestigio.—Ergo similitudo non est necessaria ad imaginationem; hæc est rerum præsentium imaginatio, non quæ actu agunt in organa sensus, sed quarum vestigia cerebro fuerunt impressa."

But it is evident that, as the images of objects are figured on the retina, they may as easily be figured on the brain, and that thus alone distinctness as well as similitude can be ensured.

As to the reproduction of impressions, it is obvious that "that which undergoes frequent or

powerful impressions of any one kind, will inevitably have its form modified by their action; and whatever new impressions or new impulses it may then receive, it will, from its better adaptation to them, have a tendency rather to repeat those acts to which its figure is perfectly accommodated, than others to which that figure would present a resistance. Thus that which has in any way acquired a conical form, whatever may be the peculiarity of the impulse upon it, tends to perform one species of motion, and that which possesses a cylindrical one tends to perform another: thus, the peculiar forms which frequent impressions produce will uniformly lead to a similar peculiarity of action; and thus, whatever impulses or impressions may be made, they may, in the simplest manner, be associated with those motions which the object is, by frequent repetition of them, best adapted to perform. Nor can it, in this case, be of the slightest importance whether the substance of which the form may be thus modified and the actions thus associated, be of earthy, ligneous or nervous matter."*

Thus, then, even in this obscure part of the process, is it probable that one motion produces another.

To all this, then, does the function of me-

* Archives, vol. 3. p. 178. July, 1809.

mory in the nervous system more or less correspond; the reason why previous actions are re-excited in the brain by impressions similar to those which first produced them, is in some measure indicated; and the cause why these operations must be less perfectly re-excited, when intermediate impressions and operations have been of a different kind, is rendered more apparent.

SECTION III.

STRUCTURE AND FUNCTION OF THE INTERCONVOLUTIONAL BUNDLES—THE ORGAN OF ASSOCIATION.

We have next to consider the interconvolutional bundles.

Reil observes, that between the interior radiating system, and the convolutions of each hemisphere, another structure is found, consisting of bundles which pass from the centre of any convolution to others more remote; that it is probable that the convolutions receive fibres both from these bundles and from either portion of the nucleus;—and elsewhere that besides what is strictly the outer wall of the capsule or white substance enclosing the outer portion of the anterior striated body, there may be raised, after the general removal of the convolutions, other white bundles, which have passed from

the centre of the base of one convolution to that of another, connecting not merely adjoining, but even remote convolutions; that these are especially found within the convolutions of the roof of the fissure between the anterior and middle lobe, whence they pass round the island or convolutions which rest on the external part of the capsule, to convolutions in the middle lobe; that this structure is probably general, and is probably intended, with the hook-like bundles which connect the anterior and middle lobes, for the common purpose of associating together in action the convolutions of the great divisions of either hemisphere; and that the substance which mechanically connects the remote convolutions in the brain, and is interposed between these and the nucleus, is permeated by more vessels, is softer, and of a browner tint, than the white matter generally.

Rolando describes, as situated above a considerable space formed by the radiating fibres of the fossa of Sylvius, a fibrous arch corresponding to the convolution which surrounds the valley superiorly and posteriorly, which he thinks is not a distinct apparatus but arises from the manner in which the bifurcating plates of this process and of superior ones display themselves. He acknowledges, however, that a similar disposition is seen in other places and especially in the occipital lobe, arising as he

thinks from the same cause. And he states that from various points of his arch, fibres ascend to the convolutions. He very reasonably thinks that the transverse fibres may be wanting in animals which have no convolutions; and he observes that they seem to be so.

Here, then, is evidently and indisputably a mode by which "not only adjoining, but even remote convolutions are connected." Now if, on these convolutions, memory be dependent, as from observation of structure and statements of pathological results, appears to be the case, then are these near and remote connexions, those by which the impressions of memory are associated.

In behalf of this view, not only do structure and observation furnish evidence, but consciousness of the operations of our own minds assures us of its necessity. We feel that the vast field of memory must be intersected by innumerable connecting paths; and, on beholding such a structure as this, and thus connected by ties infinitely multiplied and infinitely varied, we are astonished at the agreement between the moral want and the physical artifice by which it is supplied.

Since, then, memory depends on the convolutions themselves, these near and remote connexions are evidently the means of our involuntarily or voluntarily associating its impres-

sions, however varied or differing; and this is the province of association and imagination.

Association and imagination differ from memory and recollection, which consist in the re-excitement of precisely similar operations, only in this, that they re-excite and trace the analogies between operations only partially similar or more loosely connected; or that they bring together and combine circumstances, the existence of one of which leads to the conception of, and appears to require the existence of others.

The difference between association and imagination appears to be that the former is an involuntary operation; the latter a voluntary one.

The province of imagination, says Stewart, is to select qualities and circumstances from a variety of different objects; and, by combining and disposing these, to form a new creation of its own. In this appropriated sense of the word, it coincides with what some authors have called creative or poetical imagination.

This power, he adds, is not a simple faculty; but results from the combination of several different ones. The effort, for example, of the painter, in composing an ideal landscape, implies conception, which enables him to represent to himself those beautiful scenes in nature, out of which his selection is to be made,—abstraction, which separates the selected materials

from the qualities and circumstances connected with them in the memory,—and judgment or taste, which selects the materials, and directs their combination.

SECTION IV.

STRUCTURE AND FUNCTION OF THE GREAT COMMISSURE—THE ORGAN OF COMBINING AND OF IDEAS.

In birds, appears a first rudiment of the anterior part of the great commissure; and in mammalia, it is found least developed in the Rodentia.

Tiedemann says, that the great commissure results from the union of the fibres of the cerebral peduncles, after their expansion to form the hemispheres; that it is developed from before backwards in the brain of the fœtus; and that it gradually bends upwards, so as to form what Reil has termed the knee, and shoots backwards, according as the hemispheres are developed over the tubercles and the cerebel.*

The great commissure proceeds on each side, from the junction of what I should denominate the advancing and returning, or ascending and descending fibres in the hemispheres.

* Reil considers the commissure as terminated by an anterior fold [das knie des balkens], the extremity of which is narrowed into a beak [das schnabel], and again by a posterior fold [die aufgesetzte wulst].

Notwithstanding what Tiedemann and Rolando (always inverting functional order) say, after Reil, of the fibres bending from the posterior striated bodies directly to the great commissure, there are innumerable fibres which, as Reil also describes, come to the commissure from many parts of the hemispheres.

If we consider first its anterior inferior part, we find that there the extremities of the commissure appear to originate about the perforated plate near the first terminations of the olfactory nerves.

If we examine it in the lateral ventricle, we find, as observed by Reil, that in the anterior horn, especially near the fold of the commissure, where the fibres of that substance tend towards the obtuse margin of the fibrous cone, the two systems meet abruptly; that behind this the superior layers of the commissure anastomose with the bundles of the fibrous cone; that again, at the posterior margin of the posterior striated body, and for a distance of two lines from it, the bundles of each system decussate each other, and are interwoven; and that finally, the posterior portion of the commissure is extended as a distinct and separable layer within the expansion of the fibrous cone.

Reil thus distinctly notices the anastomosing layers; and he elsewhere says that the deeper bundles of either system seem most directly to

anastomose, and the inner layer alone of the commissure to pass below, and unconnected with, the fibrous cone.

But Reil also shows that the origins of the commissure are to be found throughout the substance of the anterior and middle part of the hemispheres. He observes that the anterior bundles of the fibrous cone are joined from without by the fibres radiating from the outer wall of the capsule; and that both together intermingled and interwoven, extend to the commissure. He also observes that the middle part of the commissure is in connexion with the convolutions of the inner surface of either hemisphere, with those of the vertex, and finally with those of the roof of the fissure of Sylvius.

If we examine the great commissure posteriorly, we find it equally originates in the posterior lobes; for the tapetum which Reil, always inverting functional order, describes as a layer "derived from the commissure to line the roof of the posterior horn of the lateral ventricle," is evidently, in conformity with the structure and character of the whole organ, a layer *from* the posterior lobe *to* the commissure. The unity of the organ, which is acknowledged by Reil himself, demands of us this view. We must allow, therefore, for this prevailing error when Reil says that of "the bundles, which form the posterior margin of the great commissure, and are

arranged in a full roller-like fold, a small portion is destined to unite with the arch and the long convolution, and to extend into the greater bend; and that the greater portion expands to form the tapetum of the posterior horn, the fibres of which line the bundles of the fibrous cone, crossing the latter at an angle."

While considering this part of the great commissure, we may notice the two furrows of the posterior lobe—one external, another internal behind the crested convolution, from the last of which a third runs backward toward the apex of that lobe, is seen early in the fœtus, and corresponds to the spur which is found in the posterior horn of the lateral ventricle.

These furrows, as Rolando observes, are not formed, like the greater part of the rest, from the elevation of the convolutions, but also from folds into which the internal plates are compressed; and the Wenzels state that if from the surface of the brain at the place opposite to the spur, the middle and inner cerebral membranes are removed, that protuberance disappears, so that with the extension of the cerebral surface, it is rendered level.*

* Si in superficie cerebri eo, qui eminentiae isti opponitur, loco membrana cerebri media et interior detrahitur, tuber illud invanescit, ut quamprimum cerebri superficies extenditur, in planum mutatur.—*De Penitiori Structura Cerebri, p.* 145.

Of fifty-one brains of all ages and both sexes, examined by the Wenzels with that specific view, they found only three in which the tubercle of the posterior horn of the lateral ventricle was wanting on both sides, and two in which it was wanting on one side.

Lastly, considering the commissure, as connected with the inferior part of the brain, I am satisfied that the white fibres of the greater and less bends are merely bundles from the inferior and posterior parts to the great commissure, instead of being productions of the commissure or of the arch to these parts, as is commonly imagined. The unity of the organ requires also this view of one of its important parts.

That the greater bend *belongs* to the commissure, and not to the arch, has been shown by Haller, Soemmerring, Reil, and the Wenzels.*

Beginning with the transverse striæ of the lyre as belonging to the great commissure, and as usual, inverting functional order, Reil says that the lyre, in most instances, seems to be but the extremity of the posterior fold of the great commissure, and not to derive fibres from

* Hallerus, ut ipse adnotat, primus erat, qui hippocampum ad corpus callosum referebat. Nobis imprimis taeniae continuae videntur fornici, tubera vero magna substantiae corporis callosi continuari, cum neque sufficiat fornix ad tantum horum corporum molem, neque posteriores pedes hippocampi facere possit.—*De Penitiori Structura Cerebri*, p. 136.

the inner margins of the posterior pillars of the arch; and Rolando observes that the transverse fibres called the lyre, are of a posterior formation and altogether distinct from the posterior fibres of the commissure. He indeed states that both the bundle of transverse fibres and that of the posterior pillars are separated, in the fœtus, nearly till the seventh month, from the posterior margins of the superior commissure and of the hemispheres.

He further observes that this bundle of transverse fibres (the *bourrelet* of Vicq d'Azyr) in uniting with those of the posterior pillars, expands in such a manner as to surround the brown substance which is enclosed in the greater bend, presenting a fine layer of which the fibres are spirally arranged; and beneath this transverse bundle, at a little distance from the median line, spring out two cylinders of brown substance, which enlarging, extend forward in the direction of the posterior pillars of the arch, and covered with the fibres of these pillars, and of the transverse bundle of the commissure, form the central part of each of the greater bends, in such a manner however that a margin remains open and free from white fibres, so that we see running in the direction of the thin edge, called the fimbriated body, a little cylinder or curled bend (*dentelée* of Vicq d'Azyr).

The great organ thus formed by a concentra-

tion of fibres from every part of the brain, as has now been shown, consists, in its central part of flattened bundles, disposed transversely, with their edges turned upward and downward, so as to present the appearance of transverse grooves on the surface; and each bundle consists of many delicate plates.

It is justly observed by Reil that this horizontal part of the brain forms another complete organ.

The peculiar character of this organ deserves attention. It has already been seen to be a concentration of fibres from every part of the brain. It should further be observed that it narrows even to its centre, where it is peculiarly constricted. While above and mesially, the superior raphe extends from its anterior to its posterior fold, below or opposite to this extends a similar band having a central furrow, to the edges of which the two layers of the thin partition are attached, being continued to the posterior fold of the commissure, in which and in the arch it terminates; and between this superior and inferior raphe, the commissure is, as observed by Reil, contracted, and its bundles more closely interwoven. Hence he says—"The great commissure draws itself together in the middle, from its anterior to its postérior part, toward its middle point.—Der Balken zieht sich

in seiner Mitte von vorn nach hinten gegen seinen Mittelpunkt zusammen."*

The proportional magnitude of the great commissure is worthy of notice. In man, it is developed in direct proportion to the striated bodies, hemispheres, and transverse ring.†

In quadrupeds, its parts or the bundles contributing to it, vary in this respect. The bundles it receives from the posterior horn disappear, as quadrupeds have no posterior lobes; but the greater bends are larger in proportion to the brain than in man.‡

I have thus at length described the structure and relations of this great organ, because they are so striking as of themselves to suggest its functions. As already said, the peculiar characteristic of this organ is its concentration of fibres from every part of the brain.

This characteristic is precisely the reverse of that of the organ first described in this chapter. That organ was terminal and expanded: this is central and united. And these terms are not

* *Archiv für die Physiologie, Eilfter Band, p.* 347.

† Corpus callosum tam per se spectatum quam ad longitudinem cerebri relatum in homine maximum est.—*Tiedemann—Icones Cerebri Simiarum, &c. p.* 50.

‡ Hippocamporum magnitudo cum magnitudine totius cerebri mammalium comparata manifeste ostendit, eos in mammalibus insigniores esse, quam in homine.—*Wenzels—De Penitiori Structura Cerebri, p.* 140.

arbitrarily employed; but are inseparable from the structure of the respective parts, I will not say functionally viewed, but merely traced in the order of cerebral connexion. In one of those organs, as clearly as in the other, is function consequently indicated.

The observations both of Reil and Tiedemann show, that this concentration takes place in the most distinct and, if I may use the term, the most careful manner—fibres from every point converging to form it, and these narrowing and uniting, as Reil says, even in its middle point.

But this is not all. The anatomist acquainted with the brain will at once see, that this is the part common to both hemispheres in which their fibres are, in the most remarkable degree, concentrated—the point, consequently, to which all of their actions most conspicuously tend.

It is evident, therefore, as to function, that the perceptions derived from every external impression—from every sensation, must be conveyed to, concentrated, and united in, this "other complete organ," as Reil terms it.

Now, the concentration and union of the various perceptions of an object which each sense has furnished—the combination of these in one more or less perfect image, constitutes an idea of the object.

We apply not that term to our perception of a single quality—a form, a colour, a sound, or

any other single quality; but when several of these are combined, and *that* after having been remembered, perhaps associated with other perceptions, we term the image thus composed an idea of the object.

As, then, the means of thus combining separate perceptions, are from its peculiar structure to be found in this organ and in this organ alone, I do not even use a hypothetical freedom when I denominate it the organ of combining perceptions, or, which is the same thing, of forming ideas.

To refuse assent to this, indeed, would appear to involve either a denial of the structure of this organ, or of the very existence of any such function as that ascribed to it.

I may here observe, that the greater bend being larger in proportion to the brain in quadrupeds than in man, is evidently owing to its consisting of fibres in part at least ascending from the inferior lobe, which, as already said, belongs to the vital system. As the great commissure thus consists of fibres from all parts of the hemispheres, conclusions from its magnitude compared with that of the brain can be accurately formed only by distinguishing its parts and separately comparing each.

Tiedemann furnishes, from Reil, a case which illustrates these views. The brain of man, he observes, is subject to an imperfect develop-

ment of the superior commissure, and is liable to be arrested in one of the degrees of evolution through which it passes in the successive series. Reil has reported an example of this monstrosity. "A woman about thirty years of age, an idiot, of a good constitution, and frequently employed by the inhabitants of her village in trifling commissions, fell suddenly backward, and died from an attack of apoplexy. On opening the head, independently of a slight serous congestion in the ventricles, the superior commissure presented a solution of continuity in the whole length of its middle portion, or rather this middle portion was altogether wanting; so that the posterior striated bodies were completely exposed, and the two hemispheres united solely by the slight commissure of the third ventricle, the anterior commissure, and the tubercles. Neither the knee nor middle of the superior commissure existed; and consequently, the thin partition was wanting, as it is situated in the interior of the knee. The anterior lobes of the brain were completely separated from one another in front, as far as the junction of the optic nerves and the anterior commissure; and the portion of their internal or commutual surfaces where the knee and beak of the anterior commissure usually penetrate, was covered with convolutions as the rest of the brain. The middle and posterior part did not exist. The

arch arose, as usual, from the posterior striated bodies, descended into the pisiform eminences, rose again to form the anterior pillars, ascended behind the anterior commissure, and uniting on either side with the walls of the lateral ventricles, situated immediately under the longitudinal convolutions, formed a smooth round border. Then winding round the posterior parts of the posterior striated bodies, it plunged into the descending horn of the lateral ventricles. Reil presumed that this defect in the superior commissure was the result of a retardation in the development of the brain: the details into which I have entered on the formation of the great cerebral commissure in the brain of the fœtus, fully assert the truth of his opinion."—Here a defect of the organ was attended with that defect of ideas which constituted idiotcy or want of understanding, of which ideas are the elements.

There is a deviation from the direct course of the cerebral bundles, by means of two remarkable bands of white fibres which run along the outer sides of the lateral ventricles, and which, as connected with the superior commissure, though I suspect they come from a much greater distance, may be noticed here.

Reil says, that, upon the outer margin of the anterior striated body, a substance is found,

which fills the interval at the meeting of the vertical and horizontal portions of the nucleus, where the middle bundles of the fibrous cone are bending forwards. And again—between the superior commissure and convex margin of the inner portion of the anterior striated body is found the layer of white substance which may be termed the semi-lunar border [halb-mond-förmiger saum]: its greatest breadth is at its middle, whence it tapers to either pointed extremity. . .Above it, the bundles of the fibrous cone and superior commissure meet. . .The white layer at the outer margin of the anterior striated body breaks into curvilinear processes, one lying behind the other.

I described this layer in 1809, as "commencing seemingly by minute filaments given off posteriorly by the inferior edge of the outer end of the superior commissure;" and added that "their remarkable distinctness from the medullary matter external to them and their longitudinal course, will be apparent to any one who chooses to make a horizontal section through them, and observe them with the slightest attention. They may even be entirely elevated without injury to the medullary matter of the hemispheres immediately external to them."

Reil says this band eventually joins the semicircular cord; after which, with that body, it passes around the outer margin of the posterior

striated body along the inferior horn of the lateral ventricle, uniting finally with the medulla incognita. And again—in the human brain, it becomes thinner backward, and ends toward the posterior margin of either posterior striated body in a somewhat reticular disposition: in the brains of quadrupeds, this substance is more developed posteriorly, and is the source of the tapetum.

SECTION V.

STRUCTURE AND FUNCTION OF THE ARCH—THE ORGAN OF COMPARING AND OF EMOTIONS.

In birds and in a few reptiles, the posterior striated bodies give origin on each side, to the passage of fibres to the anterior mass, by means of a small lateral bundle which winds round it downward and inward, and after passing behind the anterior commissure, ultimately forms a white radiating expansion on the inner surface of the hemisphere or inner wall of the anterior ventricle. This is evidently a rudiment of the arch and the thin partition.

In mammiferous animals, we always find the arch, thin partition and its ventricle; the radiated surfaces of the ventricles of birds becoming in them the two layers of the thin partition.

In the human fœtus, Tiedemann observes that, at four months, from the internal and inferior side of the posterior striated body, some fibres pro-

ceed from each peduncle, and descend into the pisiform eminences, where, reflected on themselves, they re-ascend to form the anterior pillars of the arch; and, that at five months, united together, the two pillars form the arch, which bending backward, covers a little the anterior part of the third ventricle.

The arch, however, appears to have two origins—one from the spinal cord, and another from the posterior striated body.

The first of these is noticed by Vicq d'Azyr, who observes that from the pisiform eminences white tracks pass toward the oblong process, forming curves of which the concavities are backward and downward; and Rolando observes, that a white cord, which comes from the peduncles of the hemispheres, or advances between them and the anterior bundles [lateral ones of other authors] of the spinal cord, directed toward the posterior striated bodies, may be considered as the origin of the apparatus of the arch.

This origin probably comes from the ascending lateral or olivary bundles.

Of the second origin of the arch, Reil says, that the root of either anterior pillar begins in either posterior striated body between its superficial plates, about a line below its upper surface, under a distinct eminence at its fore part, the anterior tubercle near the semicircular cord. Rolando observes, that it here assumes the

aspect of a ganglion from which issue a great number of fine filaments; and Meckel says it spreads out like a fan.

Now, Reil elsewhere shows that the superficial layer of the posterior striated body is continuous with the optic track, that the second layer is a production of the internal geniculate body [which appears to receive fibres from the middle root of the olfactory nerve], and that the substance between these caps, blends with the radiation of the geniculate bodies [with which both optic and olfactory nerves are connected.]

Here, then, is an obvious relation not merely of the arch, at its origin, to the returning fibres of the posterior striated bodies, but to the nerves of smell and vision, and of these again to the middle part of the brain, for in its vicinity the arch will be found to terminate. The remarkable relation of these nerves to the middle part of the brain is therefore indicated here, as well as by their more or less obvious connexion with the four tubercles and the geniculate bodies.

Of this more important root of the arch, Reil observes that it descends, being first inclined backward, then forward about opposite to the lower margin of the slight union of the posterior striated bodies, called the soft commissure [forming a curve of which the concavity is forward and downward], splits into two or three bundles, and emerging upon the under surface

of the brain, forms, by its reflection, the pisiform eminence;* that this substance contains grey matter; and that the cord prolonged from it, and termed the anterior pillar, ascends before the posterior striated body, and derives from the white border of its inner and upper margin a slender bundle at a point over against the anterior commissure. Rolando more properly considers this slender bundle as arising from the pisiform eminence, and as going along the upper margin of the posterior striated body to unite with the peduncle of the pineal gland, more visible in man than in quadrupeds in some of whom it expands like a pencil. The anterior pillar, then, having bent forward and advanced to the anterior commissure, unites behind it with that of the opposite side; and Reil observes that the con-

* Tiedemann thinks the very voluminous tubercles observed near the pituitary gland in fishes, analogous to the pisiform eminences, which corresponds with the opinion of Arsaky and Vicq d'Azyr. But this seems the less likely when we observe not only that, in the immediately superior class, they are nearly if not entirely wanting, but that they gradually increase or double only as we ascend in the higher classes. He himself says, that he has not met them at all well marked in reptiles; that, in birds, they constitute a small simple mass; and that, in the ruminantia, as the ox, hind, sheep, and goat, and in the squirrel, &c. these eminences form but a single voluminous mass, as during the first periods of fœtal life, while there are two in the carnivora, for example in the dog, fox, cat, and badger.

vex side is in adhesion with the thin partition, and gives to that body slender bundles joining those of the fillet; that the two plates of the partition rise from the anterior pillars of the arch, and proceed upwards to gain the inferior surface of the superior commissure, with which they unite.

This, he thinks, is evidently proved by the direction and radiation of the white fibres, which always proceed from the pillars towards the superior commissure expanding and inclining backwards. Rolando, however, is of opinion that the middle part of the arch and its connexion with the commissure are formed by productions from the partition, which extend even to the base; and that thence distinct layers are easily distinguished in the arch. In this course, he observes, the two cords are intimately united with the plates of the partition, and internally by a certain track covered with brown substance, which forms its internal layer.

Reil further observes, that above the anterior commissure, either pillar of the arch, before cylindrical and apart, becomes flattened, and in apposition with its fellow; that thus begins the body of the arch, which is extended directly backward, and terminates, where the lateral portions, yet further flattened, diverge, and become posterior pillars; that the inner margins of the lateral portions of the arch adhere behind to the

superior commissure, and thus close the pointed extremity of the ventricle of the thin partition; that the outer unattached margins slope downwards; that a process of the posterior pillar extends backward between the layers derived from the upper and under parts of the posterior fold, to lose itself in the convolutions of the posterior lobe of the brain; that the posterior pillar of the arch, in cônnexion with bundles from the posterior fold of the superior commissure, finally extends towards the middle lobe, to form, with the long internal convolution, the greater bend; and that the bundles from the arch form in part the covering of the bend, in part, its loose fold, the fimbriated body, these bundles being very delicate, and having a direction from within outward. Rolando states that these bundles send fibres into the brown substance of the bend, and terminate in the apex of the hook, at the extremity of the middle lobe.*

The Wenzels state that the fimbriated body, so far as they have observed, is narrower in mammalia than in man; and therefore that there is no relation between it and the increased size

* Tiedemann concludes, that the greater bend is formed by a fold of the hemispheres of the brain, proceeding inward, a particularity to which, as we shall afterwards see, the Wenzels first called the attention of anatomists; and that this fold is united to the posterior pillar of the arch constituting the fimbriated body.

of the greater bend.* The higher character of the arch than of the greater bend is thus again apparent.

The only observations I thought it necessary to make in 1809, on the course of the arch, regarded its termination, as follows:—"The course of the filaments of the fornix [arch] is obvious to the eye during a great part of it, and dissection afterward shows, that expanding into a broad medullary sheet, these filaments run from behind forward and outward under the corpora striata [anterior striated bodies], which they join at their termination in the hemispheres."— Such, at that time, struck me, in repeated dissections, unaided by any hardening process, to be their termination.—Tiedemann has since said, that the fibrous bundles of the posterior pillars, descending into the middle lobes, interlace with the expanding fibres of the peduncles: their point of termination is not well defined.

We now approach the application of these details to the function of this organ, which is evidently in itself as complete as the vertical and horizontal bundles so denominated by Reil.

Throughout the whole course of the arch from the pisiform eminences, it is evidently composed

* Medullaris fimbria hippocampi, quantum quidem observavimus, in mammalibus angustior est, quam in homine; ideoque nulla ipsam inter, et notabiliorem hippocampi magnitudinem ratio est.—*De Penitiori Structura Cerebri, p*, 90.

of *longitudinal fibres* running from below upward, bending backward, and turning downward, forward, outward, and upward again. This is a most remarkable course, and should be borne in mind, with regard to its functions.

Not less important with regard to these functions, is the statement of Tiedemann, that the arch is *formed* from below upward, and from before backward; — that its anterior pillars arise from the fibrous bundles, which proceed from the posterior striated bodies, and descending into the pisiform eminences, are there reflected upon themselves; that these bundles constitute then the anterior pillars, which inclining backward, unite to form the arch, and separating again posteriorly, descend into the middle lobes of the brain; that *thus the arch shoots backward as the hemispheres are developed and extend in the same direction;* and together with the superior commissure gradually proceeds horizontally, according as the mass of the hemispheres elongates to cover the cerebel.

Now, it is scarcely possible to conceive arguments more decisive as to the course of action in this organ. As it begins before at the fourth month of existence, consists of longitudinal fibres, and extends backward only with the influence of accumulating impressions, it is evident that whatever influence they transmit to it must

be in the direction of the growth and extension of its fibres.

The direction, then, of its fibres and of its action being evident, let us now look to the extraordinary course of this organ.—It begins among the returning fibres of the posterior striated bodies, descends to the base of the brain, ascends again, passes backward, again descends, and whether it terminates in the precise line indicated by me, or in the middle lobes generally, as subsequently stated by Tiedemann, it is continued forward, outward and upward to the points already described, where inferiorly some portion of the anterior striated bodies joins the hemispheres.

Thus its action begins in the nearly terminating action of the descending or returning fibres, diverts that action from its direct course, continues it in an indirect and circuitous one, and finally blends it with a new action or actions, passing to the hemispheres by the ascending fibres. And thus, after a long course, a previous action can reach the hemispheres only at the time when a succeeding one, by the direct course, through the peduncles and anterior striated bodies, has reached the same point.

If, then, we appeal to our own consciousness, for some analogous indication of function, we may observe, that, in order to consider two or more perceptions in connexion, and determine

their relations, it is necessary, that these perceptions should at one time exist in the sensorium; for, if they do exist, both they and their relations must, from the nature of that system, be cognizable to and, therefore, considered by it. In order, then, to be compared, and have their relations determined, it is only necessary that a preceding and a succeeding perception should, at one time, exist in the sensorium.

Now in the organ which we have just described, we find the precise physical means of effecting this; for, in consequence of the difference of the times in which, by it and by the direct course, they are conveyed, must two distinct impressions at the same instant exist in the common sensorium, and have their relations compared and determined.

Such was the view given by me in 1809 of the function of the cerebral arch.

With regard to the precise nature, however, of this function, there are some other circumstances which are yet to be taken into consideration.

This reflected action, commencing in the returning or descending bundles of the posterior striated bodies, and, after a long course, terminating in the advancing or ascending bundles of the anterior striated bodies,—this action, I say, has commenced before the returning or descending action of the former reached the cere-

bel or organ of volition. It is not affected, therefore, by the latter function.

The comparison of our perceptions, consequently, by means of this organ, is an involuntary operation.

Such being its character, it is next remarkable, that, in its extraordinary course, the arch is peculiarly connected, in other parts of the brain, with the vital as well as the involuntary cerebral system.

Independent of its first origin from the lateral parts of the spinal cord, and the apparent connexion of its second origin with the terminations of nerves in parts intimately connected with involuntary action,—independent of these, the pineal gland, of which the pedicles are united with the anterior pillars of the arch, appears to be very intimately connected with involuntary muscular action; and the pituitary gland, which the arch so remarkably approaches in the pisiform eminences, appears, as some writers have observed, to be very intimately connected with the involuntary vital system. The approach of the arch to the latter is most unequivocal and extraordinary.

The carotid arteries seem actually to make their bend in order powerfully to act upon the pituitary gland at the middle of their convexity. Their perpetual pulsation is indeed such as to flatten the sides of the gland, or to render them

concave.* The membrane stretched over the posterior lobe of the pituitary gland is peculiarly thin. The Wenzels say, "illa vero membranæ pars, quæ minorem hypophyseos lobum obducit, videtur esse tenuissima." That lobe is the softer. It is impossible, therefore, that by the remarkable bend of the carotid arteries which form the lateral walls for the pituitary gland, the state of arterial pulsation should not, through it, be communicated to the pisiform eminences of the arch. These, indeed, when we think of the preceding circumstances, irresistibly suggest the notion of the tips of two fingers dipping down, from the great organ we have described, in order to receive the impulses of arterial pulsation.

Nor is this all: the arch again comes in contact with another important part of the vital cerebral system in the anterior commissure, which is that of the middle, properly the inferior, lobes—the lobes, as will afterward appear,

* Situm ipsius inter cerebrales carotides, quae ad ipsa hypophyseos latera arcum formant, in quo aeque, ac in quovis alio, quem vasa sistunt, arcu, impulsus sanguinis praesertim vehemens est; quae hypophysin tam exacte contigunt et tam valide in ipsam agunt, ut laterales ejus facies premendo omnino planas reddant, quin adeo quandoque concavam in ipsis foveam producant, et quae pulsu per vices semper contrahuntur et extenduntur, et quae ad hypophysin vasa emittunt.—*De Penitiori Structura Cerebri, p.* 238.

of the vital system, in which terminate one portion of the nerves of smell which are especially subservient to that system.

This striking connexion of the arch with the vital cerebral system, no one will suppose to be useless. But to avoid all hypothesis, we shall merely say—the involuntary reflected action of the arch must thereby be as repeatedly and powerfully influenced by the vital system as these points of contact indicate.

Hence it is evident that the condition of the vital system must thus influence the involuntary reflexion performed in this act of comparing; and the testimony of every man's consciousness, or his mental experience assures him that such influence undoubtedly exists. Hence, in this act of involuntarily comparing, the relations of external objects to our wants will obviously be suggested.

Now, it is evident, that the relations of external objects to our wants are no sooner discovered by the process of comparing than pleasure or pain must result from their concordance or discordance with the habits of the system, or from the mode in which they affect us. It is this combination of pleasure or pain with ideas, that forms emotions.

I might here digress, in order to illustrate from this the truth, that our moral and social acts originate in personal pleasure or pain—

that they all relate more or less directly to self and vitality. But this would lead me from the present subject.

It would, therefore, at least seem probable that the arch which, commencing behind, among the descending fibres of the posterior striated bodies, dips to the base of the brain in order to connect itself with the vital and involuntary system, and then, sweeping upward, backward and downward in a curve, terminates among the ascending fibres of the anterior striated bodies, is the organ of involuntarily comparing perceptions and of producing emotions.

It is in connexion with the arch, that should be mentioned the semicircular cord.

This body exists neither in birds nor reptiles, nor does it appear during the first periods of the life of the fœtus. It is always very narrow in mammalia.

This cord consists of flax-like fibrils, which seem to arise anteriorly, by some fine filaments, nearly where the pillar of the arch meets the thin partition behind the anterior commissure. Fibrils have even been seen to join it from the anterior pillar.

It then bends outward and upward between the anterior and posterior striated bodies, sending fine medullary processes outwards into the

pecten or comb of the fibrous cone. This seems to be an important circumstance in its structure.

It becomes thicker as it passes along and turns around the posterior margin of the posterior striated body; assists in forming the tapetum of the inner half of the roof of the inferior horn of the lateral ventricle, gives fibrils to, says Reil, — receives them from, the optic track; and somewhat reticularly invests the inner half of the roof of the inferior horn.

Toward its termination, it is very near the fimbriated body (or proper posterior pillar of the fornix), being only a little more elevated. Their substances even communicate at several points; and they finally join at the hook. There, says Rolando, the semicircular line unites with the fibres which occupy the side opposite to it and which come from the fimbriated body (listerella), leaving the space which conducts to the inferior horn of the lateral ventricle.

Thus, as the semicircular line began near the commencement of the arch, so it ends at the termination of that body in the obtuse extremity of the middle lobe, which adheres to the perforated plate.

The Wenzels state that the semicircular cord in the larger mammalia is absolutely, in the smaller proportionally to the size of the brain,

thicker and broader than in man.* Thus it ranks in character rather with the greater bend than with the arch itself. This is confirmed by Reil's observation, that fine fibres from the anterior commissure may be traced to the medulla incognita and to the semicircular cord; for both that commissure and the medulla incognita belong to the vital system.

I now return to the connexion of this body with the comb; for to this, its functions seem especially to relate—for this, it appears to leave the arch at its beginning, and to join it at its termination.

Rolando says that, by scraping away the brown substance from the convex face of the posterior striated bodies, we see many fine white fibres which come from its internal surface and expand in arriving at their circumference, to pass under the internal striated body; that at this point they (the fibres of the posterior striated bodies) are interwoven with the fibres of the semicircular line so as to become collected in more distinct bundles, posteriorly larger, and anteriorly more divided by the interposed brown substance; and that from these fibres is formed a layer which comes into contact with the layer

* Praeterea majoribus in animalibus absolute, in minoribus autem proportionate ad magnitudinem sui cerebri crassior atque latior, quam in homine est.—*De Penitiori Structura Cerebri, p.* 89.

of the peduncles, and is closely united with it by means of the interlacing produced by the fibres of the semicircular line which extend much outward. And again, he says that this bundle, in proportion as it extends backward, sends off fine fibres which entwine with others from the posterior striated bodies; that by that means these become distributed in bundles much more distinct than in other parts; and that this interweaving between the fibres of the semicircular line and those of the posterior striated body, appears to extend in part to the fibres of the peduncles, in consequence of which these two layers are intimately conjoined in that direction.

From this it would appear, that the semicircular line separates from, and rejoins, the arch, for the purpose of interweaving with the fibres of the posterior striated body, and in some measure with those of the peduncles, of thereby intimately conjoining these two layers in that direction, and of collecting the former in bundles much more distinct there than in other parts. As, therefore, the semicircular line belongs to this involuntary organ, it is not improbable that it exerts an involuntary influence or impresses an involuntary direction upon the returning motions of the posterior striated bodies, at the very moment when they are descending to join

either the cerebel or the involuntary bundles on the sides of the tubercles.

SECTION VI.

STRUCTURE AND FUNCTION OF THE CEREBELLIC RING — THE ORGAN OF DETERMINING AND OF PASSIONS.

This commissure produced by the lateral peduncles, is found in all mammiferous animals. Its size is in direct proportion to the development of the hemispheres. Both are least in the rodentia.

The transverse ring is generally separated into a posterior and anterior portion.

Like all the posterior parts or their productions, it is remarkable, that this part appears about the fourth month.

Tiedemann says, that the transverse ring not existing before the third month, we can perceive the spinal cord continuous with the peduncles of the brain, as in fishes, reptiles, and birds, which are equally destitute of this eminence; that according as the ciliary bodies and hemispheres of the cerebel increase, the transverse ring, thin and narrow at first, augments in breadth and thickness; that in the fourth month it proceeds from the rhomboidal bodies, and from the white substance of the cerebel, appearing as soon as the formation of the medullary nuclei; and that, in the fourth month only, the

period when the rudiments of the ring have appeared, the limits of the oblong process are marked by the transverse fibres of this protuberance, which unite together beneath the two hemispheres of the cerebel. It is yet but one line in its longitudinal diameter.

Inverting, as usual, functional order, Reil tells us, that the lateral and inferior peduncles throw themselves inward over the superior, to unite with their fellows in the superior vermiform process; and that the lateral peduncles, followed backward along the horizontal fissure, internally divide into an upper and an under layer, the fibres of which in part pass inward toward the vermiform processes, in part radiate backward to be distributed to the posterior lobes of the cerebel. Adopting, then, the functional order (for such is the utter disorder which neglect of function induces, and it cannot be better exemplified), he says that the lateral peduncles, with their continuations, form a ring encircling the other parts of the cerebel; and that this ring is completed on the fore part by the annular protuberance, in which the substance of the peduncles is spread out in strong and coarse bundles, so disposed as not to preserve a uniform distance from the surface, but now to approach it, now to recede from it, and in parts to cross each other.

Reil particularly states, that the ring is

formed by the interweaving of the lateral peduncles of the cerebel with the bundles of the pyramids, and that all the other portions of the oblong process, as well as the remaining peduncles of the cerebel, are placed behind this mass.

Such are the condition of this organ in mammalia, its growth in the human fœtus, and its general structure.

That it is of higher function than some other parts is proved by its being found only in the highest class of animals, by its being larger in man than in apes and quadrupeds,* by its increasing according as the hemispheres of the cerebel, which belong also to the highest class, become more voluminous, and by its being developed in the direct ratio of the hemispheres of the brain, and in the inverse ratio of the middle [inferior] lobe, the tubercles and the spinal cord.

Now it has been seen, that the pyramidal bundles are the ascending ones, or those by which the motions of sensation are communicated to the brain, and also that the descending fibres of the transverse ring interlace with and doubtless act upon or blend with these. Indeed, it is evident that the fibres of the ring

* In his Icones Cerebri, Tiedemann says "Nodus encephali, seu protuberantia annularis, quae hemisphaeria cerebelli tanquam commissura in parte inferiore connectit, in homine major est, quam in simiis et mammalibus.

descend only so to act or blend; for no other purpose is apparent from their structure.

To illustrate this, I may observe that the formation of a mere commissure might very shortly have been effected by a crossing above, and without a descent to surround the oblong process; but if, on the contrary, it was necessary to blend fibres descending from the cerebel with some of those ascending to the brain, it could be done only in this way, because the one is behind and the other before, and, not to interfere with internal parts, it was necessary that the former should pass to the latter externally.

Even supposing that this descent of fibres from the cerebel serves other purposes, it is at least evident that it serves this one, and that so conspicuously, that no other is apparent.

The effect of such a blending of cerebellic with cerebral action, must obviously be a modification of the latter, for the physical junction is such, that, while the cerebel could be influenced only laterally, through an appended off-shoot, and out of the course of its general action from before backward, the brain, through the comparatively slender pyramid, which swells into the fibrous cone, is influenced directly in all the vast radiation of its ascending masses.

As then, the cerebel is the organ of the will, the modification which ensues must be, in a greater or less degree, the subjection of perception

and its effects to the will—the voluntary direction or determination of mental operations. Certainly, no sooner are circumstances compared, their relations to our wants rendered evident, and emotions, pleasurable or painful, their result, than determination respecting them must follow.

If the cerebellic or voluntary direction or determination of cerebral operation be applied to emotion, it must constitute passion; for will, combined with pleasurable emotion, must be desire, and, with painful emotion, aversion.

In animals below mammalia, which do not possess this organ, passion must in all cases, be a direct and unreflected act.

Thus, as in man, ideas are the results of combining, and emotions the results of comparing, and passions the results of determining.

On the transverse ring, then, which descending from the cerebel or organ of volition, embraces all the bundles of nervous fibres ascending to the brain, and interlaces with the anterior ones, depends the internal application of the will, and it is therefore the organ of voluntarily determining, and of producing the simple passions of desire and aversion.

When these are in excess, they will probably be again propagated to the organ of volition; and an external act will be induced. It is, indeed, when thus powerful, instantaneously pro-

pagated to the cerebel, and producing evident locomotion, that they commonly receive the name of volition.

Hence, volition must be implicitly dependent on intellect, as that is dependent on sensation, and it, upon external impression.

From this, I would deduce an illustration of the nature of moral necessity. As sensation is implicitly dependent on external objects, perception on the combining of sensations, emotion on the comparing of perceptions, passion on the internal determining of the will, and external volition on such desire or aversion,—as in fact, these differ from each other only in as much as the continuance or termination of motion differs from its commencement, volition or will is evidently the termination of a series of dependent motions—it is the offspring of preceding motion and nothing more—it may thus in itself be termed necessary, and can have no other source of existence.

Hume erred in asserting, that necessity, understood either morally or physically, must be painful; and that expression has probably obscured the question.

The unnoticed difference between external and mental necessity, is that the former is independent of mind, and may either accord or discord with the will, while the latter is the creature of mind, and, as the effects of the same

cause cannot disagree—as the results of the same motion cannot be opposed to each other, necessity and will must therefore always accord and accompany each other.

This contest, therefore, has been undecided, merely because it has not been observed, that they are both mere concomitant and inseparable functions of the mental organs of the human body, and it shows us that moral philosophers ought to be anatomists and physiologists.—They must first know the structure of an acting body, before they can know its actions, or reason respecting them.

Will and mental necessity, instead of being at variance, are perfectly accordant—the one cannot subsist without the other.

Fibrils seem even to arise in the substance of the cerebellic ring and to join the cerebral peduncle.—Thus, evidently, the cerebel sends its influence upward to re-act upon remoter parts of the brain; and it is doubtless by such means, that memory and association are subjected to the influence of the will, and that the former becomes recollection or conception, and the latter imagination.

SECTION VII.

STRUCTURE AND FUNCTION OF THE VENTRICLES — THE ORGAN OF CONSCIOUSNESS.

In fishes generally, and in birds always, the number of ventricles is six; four corresponding to those of man, and one in each superior tubercle.

Serres, however, considers the lateral ventricles properly so called as absent in all but man and mammalia, in whom the tubercles are solid, while they are the reverse in the three inferior classes.

In mammiferous animals, we find both the anterior and descending horns; and the former are continuous in the carnivora, rodentia, ruminantia, and solipeda, as in the fœtus, with the enlargements of the olfactory nerves, sometimes termed mammillary eminences.

As to the proportional magnitude of the parts of these ventricles in mammalia, the Wenzels make the interesting observation that their superior part appears to have nearly the same proportion to the magnitude of the whole brain as in man; but that the extent of the descending or inferior horns far exceeds, if we compare their ratio to the magnitude of the whole brain, with the proportion between the same parts in

man.* This is another confirmation of the observation I made as to the vital and inferior purposes to which the greater bend, &c. were more or less subservient.

With the want of the posterior lobe in mammalia, the posterior prolongation of the lateral ventricles is wanting.†

Tiedemann observes that the radiation of the fibres of the peduncles in front, laterally, and behind, their direction from without inward, and the course which they pursue afterward from above downward, to form the superior commissure as also the greater bend, explain the manner in which the lateral ventricles are formed.

Reil had previously said, that the ventricles result from the horizontal apposition of the superior commissure to the ascending and diverging peduncles; that properly there is but one

* Superior eorum pars ad magnitudinem totius cerebri fere eandem habere proportionem videtur, quam superior lateralium ventriculorum pars in homine ad magnitudinem totius cerebri ejusdem habet; sed...ambitus cornuum descendentium, seu inferiorum rationem ad magnitudinem totius cerebri, si cum proportione cornuum descendentium in lateralibus ventriculis hominis ad magnitudinem totius cerebri ejusdem comparemus, longe superat.—*De Penitiori Structura Cerebri, p.* 196.

† Cornu posterius in simiis et phocis brevissimum et vix conspicuum est; in ceteris mammalibus plane desideratur.—*Tiedemann—Icones Cerebri Simiarum, &c. p.* 54.

extensive cavity, which surrounds the posterior striated bodies, extending (as the third ventricle) below them to the infundibulum, and through the passage from the third to the fourth ventricle; and that this is not every where enclosed by cerebral surfaces, but is open below the lyre, or posterior part of the superior commissure, and at the lower aperture of the fourth ventricle: and he described also the epithelium as a leathery substance, partly membranous, partly consisting of nervous matter, which invests such white surfaces of the brain, as want other coverings.

The third ventricle, as well as that of the thin partition, is larger in man even than in apes, and much more so than in other mammalia.*

The fourth ventricle exists always in fishes, reptiles, birds and mammiferous animals; is continuous with the third; and in fishes communicates with the canal of the oblong process, and can in them be considered only as a dilatation of it.

The fourth ventricle is also proportionally larger in mammalia than in man.† In mam-

* Ventriculus tertius et ille septi lucidi in homine relati ad magnitudinem cerebri maximi observantur. Hi ventriculi in simiis minores, inque reliquis mammalibus parvi et valde angusti sunt.—*Tiedemann—Icones, p.* 54.

† Ventriculus quartus seu rhomboidalis in simiis et mam-

malia, moreover, it is larger than the third ventricle: in man, it is less.*

Now, in observing the internal surfaces of the lateral ventricles, it will appear that they are nearly all composed of the white, fibrous, substance of the brain, and that they owe this chiefly to the concentration of fibres from all parts of the hemispheres toward the superior commissure.

As the centralization of these was necessary to combining perception in forming ideas, their previous expansion in appropriate cavities was easily permitted; and, when we observe the various and remote sources from which they arrive, and the long course during which many of them are exposed, the fact appears sufficiently striking to cause reflexion.

Not only do we see these fibres forming the roof of the superior part of the lateral ventricle, but we find them coming numerously from before and consequently thickening the anterior part of the commissure where they cross. More remarkably still do we see them ascending as the greater bend, its additament, &c. (for indeed the inferior portion of the lateral ventricle seems

malibus relatus ad magnitudinem cerebri multo major est, quarto ventriculo hominis.—*Tiedemann—Icones, p.* 54.

* In mammalibus nempe manifeste multo major quarto ventriculo, in homine contra minor est.—*Wenzel—De Penitiori Structura Cerebri, p.* 197.

chiefly, and the posterior horn entirely, to serve the purpose of giving expansion to their white lining or tapetum generally passing to the great commissure), and consequently thickening correspondingly the posterior part of the commissure. As already said, the direction of the cerebral fibres being toward, and not from, the commissure, as Tiedemann's observations prove, renders it probable that the greater bend, &c. are no other than fibres from all the inferior and posterior convolutions ascending to the commissure, and the thickening of its posterior part, where they are collected, confirms this.

It indeed appears that each of the great parts of the brain has its representative in the ventricles. The whole of the ascending and descending masses have theirs, as we have seen, in the expansions passing from them to the great commissure. The commissure itself, to a great extent, constitutes the walls of the ventricles. The convolutions and interconvolutional bundles have their representatives in some portion of the greater bends, as the Wenzels have shown.*

* The details of the Wenzels on this subject are so interesting that I give them in a note.

Re accuratius investigata adparet, partem superficiei cerebri, sive unum gyrorum ad basin cerebri et quidem inferiori parieti descendentis cornu perpendiculariter oppositum in cavum istius cornu, sive introrsum continuari, ideoque de exteriori atque inferiori parte interiorem ac superiorem versus

The arch is nearly throughout exposed in the ventricles. Thus all the great cerebral organs may be said to be exposed in these cavities.

inflecti. Exterior igitur paries cerebri, gyros constituens atque ex cinerea portione constans, inflectitur; dum autem inflectitur, ad exteriorem ejus faciem subtilis admodum tenuis, medullaris lamina, illius decursum comitans, adclinatur.

Inde postquam ista superficiei cerebri continuatio, sive gyrus ille in descendentis cornu cavum pervenit, ibique adsurgit, statim interius dicti cornu integumentum, videlicet descripta superius alba medullaris lamina superficiei illius gyri se applicans, eum obducit atque comitatur.

Hoc igitur modo incipiens gyrus exterius ex alba, tum vero ex cinerea de cerebri superficie proveniente, et denique rursum ex medullari pariter extrinsecus adveniente portione constat.

Dum ergo tres istae, proxime sibi adjacentes, ac intime inter se connexae laminae quatuor circiter, aut quinque linearum spatio ulterius continuantur atque adsurgunt, exinde autem introrsum inflectuntur, corpus illud enascitur, quod hippocampus adpellatur. At paulo post laminarum istarum inflectionem, illarum exterior in hippocampi fimbriam transit; media et cinerea finitur, postquam paulo angustior facta est; tertia porro angustissimaque medullaris lamina pariter desinit.

In universum igitur tres istae laminae in suo decursu romanam literam S referunt, cujus exterior et inferior curvatura basi descendentis cornu expletur, cujus superiori autem ac interiori flexurae specialis illa, quam supra jam commemoravimus, subrotunda cinereae substantiae portio inseritur, eamque apte explet.

Hippocampus ergo, manifeste nihil aliud est, nisi continuatio superficiei cerebri intro flexa, sive in unam lateralium

This expansion, then, of white and fibrous matter from every part of the brain—this bringing of all of them to form the sides of a cavity, is one of the most remarkable circumstances in the organ.

To appreciate the capabilities which must result from this, it is necessary to observe, that the difference between the condition of fibres collected in a commissure and those expanded on the sides of cavities, is evidently this, that the former are fixed and cannot be separated, while the latter may either be in contact or separated by an interposed vapour or liquid.—And such pre-

ventriculorum partem; sive hippocampus nil est, nisi unius gyrorum in superficie cerebri sitorum in interius cerebri, seu in quamdam lateralium ventriculorum partem prolongatio.

Cum vero ista gyri, seu superficiei cerebri prolongatio non redeat usque ad exteriorem superficiem; sed in descendente lateralis ventriculi cornu finiatur, dici potest, superficiem cerebri, sive gyros in superficie cerebri sitos in lateralibus ventriculis vel terminari, vel incipere.

After some speculation as to a supposed relation of this structure to the nerves, they add:

Ita et mutationes interiore in cerebro productae hippocampo tamquam initio gyrorum et superficiei cerebri immediate communicari, atque inde ad omnes reliquos cerebri gyros, totamque cerebri superficiem deferri possunt ac propagari.

Quaestionem ergo, quam saepe ipsi nobis movimus, et quae fors etiam aliis oborta jam fuerit, ubinam videlicet gyrorum cerebri initium aut finis sit, hac ratione solutam esse credimus.—*Lib. cit. p.* 140.

cisely is the case with this admirable expansion. Its functions are the result of this variability.

Let us first consider the state of contact of these parts in the ventricles, which appears to be their ordinary state.

We see here an elaborate expansion of the most highly organized cerebral substance from every quarter ; and it appears evident, from such delicate apposition of these various parts, and the peculiar relations which are thus established between them, that no particle in any one can be deranged without affecting all the rest, and that every separate action must thus be impressed upon the whole.

Indeed, under less favourable circumstances, all the actions which take place in the system must be more or less cognizable to it, and the actions of other systems can be cognizable only by means of it. But in this particular case, the means are so accurately adapted to the end of mutual cognizance, that it is obviously from this beautiful arrangement that consciousness arises.

Consciousness is in truth nothing more than the cognizance which thus the common sensorium has of its own operations. It differs from sensation in this, that that function refers to external acts ; this, to internal. It is a mere new name for sensation, when applied to internal, instead of external operations.

As our knowledge of all that is without us,

rests on facts ascertained by sensation, so our knowledge of the mind rests on facts for which we have the evidence of consciousness.

Sensation without consciousness is exemplified in the vital system: there is no need of a new word for it. Properly speaking, sensation never is accompanied by consciousness: it is perception which is.

From consciousness and memory, as observed by Stewart, we acquire the notion, and are impressed with a conviction, of our own personal identity. We cannot properly be said to be conscious of our own existence; our knowledge of this fact being necessarily posterior, in the order of time, to the consciousness of those sensations by which it is suggested. The belief with which it is attended has been considered as the most irresistible of any.

The doubleness of the organs and the unity of the functions are perhaps chiefly reconciled by the superior commissure, &c. forming the sides of this organ of consciousness.

SECTION VIII.

STRUCTURE AND FUNCTIONS OF THE CEREBRAL GLANDS* IN RELATION TO THE VENTRICLES — THE ORGAN OF SLEEP.

We have next to consider the state of separa-

* These cannot properly be termed superadded parts, but their connexion with the latter, requires consideration here.

tion of the sides of the ventricles, which would obviously cause the absence of the function depending on their apposition—that is, the absence of consciousness.

The organs on which the existence and duration of this state depend, appear to me to be the pituitary gland and the pineal gland.

The most whimsical conjectures have been formed as to the uses of these bodies, and especially as to the pineal gland. As it is rendered conspicuous by being nearly detached from surrounding parts, its importance has been even exaggerated; so that it was reckoned by Des Cartes the seat of the soul! And as the gritty matter in it became proportionally interesting, an office no less odd was found for it by an old anatomist. He had observed this matter more frequently in the brains of Frenchmen than of Dutchmen; and as he was perfectly aware of the levity and unsteadiness of the former, he conjectured that the little stones in this little organ of the soul were intended by Providence to balance and steady them. The hypothesis, I believe, was thought a very rational one, till some other person observed, that unfortunately for the French, this arrangement of Providence had not answered the purpose!

On contemplating the relations of these bodies, with a view to discover their functions, I could not help being struck with various cir-

cumstances respecting them, which do not appear to have been brought together before,—their being both similarly detached in a great measure from the brain,—the situation of one of them at one extremity of the middle ventricle, and of the other at its opposite extremity,—one being attached to the great arteries, and the other to the great veins of the head,—the structure of both resembling that of glandular parts, —one being fixed to the beginnings, and the other to the ends of the optic tracks,—one encreasing, and the other decreasing with age,—one connected entirely with the vital, and the other with the involuntary system,—one being placed almost out of the brain, and the other in its very centre.

Such is precisely the general view of the relations of any organ which I would recommend to the philosophical student as the fact-basis, not yet of any conclusion, even of a hypothetical nature, but of a comparison with whatever we may know of function elsewhere under similar circumstances, in order to trace out a more perfect analogy between the structure and functions of particular parts, and ultimately to obtain, not from fancy, but from all we can at first discover of fact and function, a rational hypothesis, which further knowledge may, or may not, convert into a theory or true doctrine.

Let us, then, consider each of these circum-

stances in detail as to each of these organs, and *first* as to the pituitary gland—because it is it which is first observed both in the classes of animals and in the fœtus.

As to position and detachment from the brain, I may restate, that immediately behind the commissure of the optic nerves is the grey tubercle which extends backward to and in some measure envelopes the pisiform eminences, forms part of the floor of the third ventricle, and contains in its centre a small portion of white substance; and that from the middle of this tubercle, descends obliquely forward the slender conical prolongation, of reddish colour, called the pituitary stem which passes under the commissure, and terminates in the pituitary gland, lodged in a remarkable cavity of the sphenoid bone.

The pituitary gland, thus detached, is rounded and transversely elongated; convex before, notched behind, and of the form of a kidney; of greyish colour; and is surrounded by the outer membrane, except at its upper part, on which the middle membrane is expanded.

We are thus entitled to conclude that the function of this body is as much detached from the cerebral functions, as its substance is from the brain itself—that, instead of being intrinsic and essential, it is extrinsic and accessary.

As to the relation of the pituitary gland to the ventricles, it is placed below the anterior part

of the middle or third of these cavities; and the fact stated by Tiedemann that, in the fœtus, the third ventricle passes down, like a funnel, into it (indem sich die dritte Höhle als Trichter in ihn hinabsenkt), places this relationship in a most conspicuous point of view.

We are thus entitled further to conclude, that whatever that function is, it relates chiefly to the ventricles; and as the peculiarity of the ventricles, with which alone such bodies are connected, is that they are cavities, sometimes filled with vapour or liquid, and sometimes empty, it is not unreasonable to suppose that this body has some connexion with that variable state of the cavities to which it is appended.

Of the relation of this gland to the arteries, the Wenzels have observed that its situation is on all sides strongly protected against every shock or disturbance . . . that it is between the carotid arteries, which form even by its sides their bends, in which, as in all similar parts formed by vessels, the impulse of the blood is especially vehement; and these are so perfectly in contact with, and so powerfully act upon it, that, by their pressure, they render its lateral surfaces quite flat, or sometimes even produce in each a depression; while they are always alternately contracted and extended in pulsation, and send vessels to the gland itself.*

* Firmum, contra quemvis succussum, aut dimotiones

From this extraordinary relationship to arteries, we might still further conclude that this body, for which its general aspect has procured the name of gland, is really of a glandular nature.

As to structure, the pituitary gland is evidently composed of two distinct yet connected portions. The first of these portions, which is the largest, is anterior. This consists of two substances, a red external, and a white internal one, which in the natural sound state are always evident. The posterior portion which is smaller, is soft, pulpy, and impregnated with a whitish viscid liquid.

It is also traversed by vessels, and possessed of a secreting apparatus, consisting of fossulæ and canals.*

quascunque ex omni parte tam valide munitum hypophyseos situm. . .Situm ipsius inter cerebrales carotides, quae ad ipsa hypophyseos latera arcum formant, in quo aeque, ac in quovis alio, quem vasa sistunt, arcu, impulsus sanguinis praesertim vehemens est; quae hypophysin tam exacte contingunt et tam valide in ipsam agunt, ut laterales ejus facies premendo omnino planas reddant, quin adeo quandoque concavam in ipsis foveam producant, et quae pulsu per vices semper contrahuntur et extenduntur, et quae ad hypophysin vasa emittunt.—*De Penitiori Structura Cerebri*, p. 238.

* Ad portionum istarum terminos, loco, quo ambae se contingunt, sive quo rubra desinente, alba incipit, . . . in utroque latere, . . . parva quidem, attamen primo jam obtutu clare conspicua, rubra, quodammodo triangula, aliquantum

There appear, moreover. to be communications from the cellular structure of the gland and especially from the posterior lobe to the third ventricle, as the Wenzels have shown, in the passage quoted below.*

oblique sita reperitur fossula, cujus anteriorem in marginem, ut saepius manifeste a nobis observatum est, plura, quasi in fasciculum collecta, subtilissima, fossulam versus in morem radiorum concurrentia, in rubra substantia sita vascula, sive canaliculi inseruntur, de cujus posteriore margine canaliculus abit, sat magnus, plus minusve rubens et si dissectio hypophyseos quam optime successerit, semper conspicuus, qui de fossula oblique ad centrum posterioris marginis anterioris lobi, sive ad centrum sinus in posteriore margine anterioris lobi, sive, ad locum insertionis infundibuli semper procurrit, ibidemque terminari videtur.—*Ibid. p.* 213.

* Ex his igitur verisimile est:

Quod interior structura infundibuli cellulosa sit;

Quod directio cellularum de hypophysi ad cerebrum, non de cerebro ad hypophysin procedat;

Quod injectiones per posteriorem lobum modicam tantum, per infundibulum autem magnam vim requirant;

Quod etiam exhalatum aliquod fluidum vi volatilitatis suae de hypophysi per infundibuli cellulas in cerebrum ascendere possit, idque multo facilius, quam liquor guttatim fluens gravitate sua de cerebro per infundibuli cellulas in hypophysin;

Quod initium infundibuli prope hypophysin, finis ipsius prope cerebrum sit, sive, quod infundibulum ex hypophysi oriatur et in cerebro desinat;

Quod infundibulum cum utroque hypophyseos lobo cohaereat; subtilioribus vinculis cum anteriore, magis analoga ratione substantiae suae cum posteriore lobo. — *Ibid.* p. 232.

These circumstances corroborate the previous conjecture that the pituitary is a secreting gland, and when added to the preceding views, they render it difficult to avoid concluding with the Wenzels, that from the blood circulating in the red portion of the anterior lobe, by aid of the special canals inserted in each of its fossulæ, a peculiar liquid is secreted in these fossulæ, which, carried to the infundibulum by the peculiar and more remarkable canals passing from the fossulæ, is then by the cells of the infundibulum conveyed and distributed to the third ventricle, and thence to all the ventricles of the brain; that the structure of the pituitary gland, so perfectly analogous to that of secreting organs, leads us to the reasonable conjecture that it belongs to the same class, and that it must therefore have great influence over the brain, &c.; that, as the singular importance of this function of the gland, uninterrupted throughout the whole course of life, is already evident from its situation between two such remarkable arteries, so there is no doubt that, by their continual pulsation, its functions are preserved, promoted, and according to circumstances, encreased or diminished.*

* Quod ex sanguine in rubra portione anterioris lobi circulante, ope specialium in utramque fossulam se inserentium canaliculorum, proprius quidam liquor in fossulas secernatur, qui. . .per peculiares insignioresque de fossulis abeuntes canaliculos ad infundibulum delata. . .denique per infundi-

From all that precedes, then, I seem warranted in the final conclusion, that that which is secreted by this gland is the vapour or liquid of the ventricles.

Its relation to the beginning of the optic tracks is really curious. The infundibulum is placed within, and the gland immediately below, their bifurcation. That one of these parts influences the other, cannot be doubted.

If, then, the expansion of the middle ventricle caused by this secretion be a condition of sleep, as I shall endeavour to show, it will well account for the pressure or weight which is always felt on the eyes at the approach of that state. It deserves to be noticed that, in an infant, the mere shutting of the eyes at its mother's bidding, shall immediately bring sleep.

As to its first magnitude and subsequent de-

buli cellulas in quartum ventriculum, atque inde in omnes cerebri ventriculos deferatur atque distribuatur;

Quod ea, secretoriis organis tam valde analoga hypophyseos structura in justam nos conjecturam adducat, ipsam in classem eorum referendam esse, ideoque eam immediate in cerebrum, uti et mediate in totum corpus influxum non mediocrem habere;

Quod, quemadmodum singulare momentum non interruptae per totum vitae decursum functionis hypophyseos ex suo inter duas tam insignes arterias situ jam elucere videtur, ita pariter nulli dubio obnoxium sit, per continuatam toto vitae tempore pulsationem ambarum illarum arteriarum. . .functiones ipsius conservari, promoveri et pro ratione circumstantiarum augeri minuique.—*Ibid. p.* 239.

crease, I may now observe that the pituitary gland is found of very different size, in fishes, reptiles, birds, mammiferous animals, and man in particular, and that, in man, it undergoes a signal change in advanced life.

In fishes, Carus says, that the inferior surface of the middle cerebral mass presents some elevations, consisting of grey substance, corresponding precisely to the grey substance about the infundibulum in the human brain; that there are usually three such projections, of which the middle one is always, and the lateral ones generally, hollow; that to the middle one, the pituitary gland is attached by means of the infundibulum; that it is lodged in a depression in the cranium, consists of two kinds of substance, and is very large in proportion to the brain. Tiedemann says, that in fishes, it is of enormous size in proportion to that of the brain.

In reptiles, Carus says, there are no longer any distinct ganglia on the under surface of this mass, but merely as in man, an accumulation of grey substance at the intersection of the optic nerves, together with the pituitary gland, which is proportionally very large.

In birds, he says, the inferior surface of the second cerebral mass also presents an accumulation of grey substance, and has attached to it, by means of a short infundibulum, the pituitary gland, which is lodged in a tolerably deep

groove at the base of the cranium, and in comparison with the brain is smaller than in the preceding class.

In mammalia, he says, the pituitary gland is in most respects like that of the human brain, except that it is proportionally larger. The Wenzels had previously shown this to be the case, especially in herbivorous animals.

Tiedemann has shown that the pituitary gland even of monkeys is much larger in proportion to the brain than in man.

Than all this, however, a comparison of the pituitary gland with the ventricles would be more useful.

In the fœtus, Tiedemann informs us that the pituitary gland is not in existence in the second month, nor even at the commencement of the third; that it appears toward the end of this second period, forming a large soft mass; that in the fourth, fifth, and sixth months, it augments considerably in size, and represents a pyramidal hollow body, for the third ventricle is prolonged into its interior; and that in the course of the following months, it nearly resembles that of the adult.

Of all the parts of the brain, say the Wenzels, there is none which seems so greatly and so remarkably to decrease in advanced age,*— a striking characteristic of a secreting part.

* Inter omnes, quae ad humanum cerebrum pertinent,

As to its relation to the vital system, the pituitary gland, like the nervous organs of the vital system generally, is placed forward; and it is at the same time between the middle lobes of the brain appropriated to vital perceptions.

In the coluber natrix, Carus found an evident communication between the pituitary gland and the sixth pair of nerves. H. A. Meckel, also, found, in the goose, fibres connecting the same part with the third pair. As these nerves are closely related to the ganglionic system, the pituitary gland has, for this reason especially, been thought to represent that system within the scull, and to form the cephalic extremity of the sympathetic nerve.

This gland seems indeed to bear the same relation to the vital system, that the pineal gland bears to the involuntary muscular system.

This is quite conformable to its being a se creting organ, of which the function and the power must depend entirely on the predominance of the vital over the mental system. Hence also the pituitary gland, is placed much more than the pineal gland, out from among the cerebral masses.

We have now to consider the pineal gland, in these various respects.

As to position and detachment from the brain,

partes nulla tam insigniter atque notabiliter in provectiori aetate, quam hypophysis, decrescere videatur.—*Ibid. p.* 236.

this body is situated beneath and behind the arch, in the folds of the inner membrane, and above the four tubercles. It is of the size of a large pea, but varying somewhat in form, of a soft and pulpy consistence, and of greyish colour. Like a foreign part, it is detached from the substance of the brain.

Here again we are entitled to conclude that there exists a corresponding detachment of function.

In relation to the ventricles, it ought also to be remarked not only that the pineal gland is placed at the upper part of the third ventricle,* but that it is between the pineal gland and the choroid web that the posterior orifice of the arachnoid canal occurs.

We are accordingly entitled to conclude that whatever that function is, it relates to the cavities of the brain and their variable state.

The relation of the pineal gland to the veins is as remarkable as that of the pituitary gland to the arteries.

In birds, says Tiedemann, it is situated behind the hemispheres of the brain, immediately

* Nonne notatu dignum est, say the Wenzels, quod hypophysis cum uno, conarium cum altero opposito quarti ventriculi termino, connexa sint? quod ambae partes mediate, hypophysis per infundibulum, conarium per medullosam commissuram cum hoc ventriculo conjunguntur?—*Ibid. p.* 237.

under the inner membrane, where it is united to it by delicate vessels; and Carus observes that, at the anterior extremity of the aqueduct, where the larger venous trunks of the brain unite, the pineal gland is placed, being firmly attached to those vessels.

Among mammalia, says Carus, the pineal gland is firmly attached to the veins, in the rodentia, the mole, and the hedgehog.

In the fœtus, Tiedemann observes, that it adheres constantly to the inner membrane by delicate blood-vessels.

From this relationship to veins, as remarkable as that of the pituitary gland to arteries, we may further conclude not only that this body, as its name implies, is really a gland, but that it is a gland of absorption—a function closely connected with the venous system.

The absence of absorbents in the substance of the brain appears to me to be essential to the permanence of impressions upon its substance; and though, in the middle membrane, Mascagni and Ludwig assert their having seen lymphatic vessels, yet they appear to be few in number, and they probably answer only its own purpose, and do not affect the great cavities which seem to require an organ peculiarly adapted to them.

Structure and several circumstances support this view.

Like the absorbent glands in some animals

the pineal gland is hollow, and has its cavity turned toward the middle ventricle, as more particularly described by the Wenzels in the following note.*

Tiedemann says he has not observed concretions in the pineal gland of reptiles or fishes. Neither he nor the Wenzels have found them in that of any mammiferous animal.† The former has not found them even in monkeys.‡ The

* In anteriore et latiore conarii termino semper, ubi conditio plane naturalis erat, absque exceptione reperiebamus scrobiculum, in diversis tamen diversum, modo minorem, modo majorem, hic magis, alibi minus profundum, qui quandoque in quoddam cavum usque ad medium adeo conarium procedens prolongabatur.

Scrobiculus iste ad quartum cerebri ventriculum conversus est, partim medullosis ad colliculos opticos pertinentibus striis, partim medullosa, quae cum posteriore commissura cohaeret, taeniola cinctus, et, nisi oculus fallit, subtili admodum, ac tenui medullosa lamina abductus est.—*Ibid. p.* 151.

† Quadrupedes, id quod notatu dignum est, nullum videntur habere acervulum; saltem in duobus diversae aetatis equis, in bove ac cervo, in duabus ovibus, in vitulo et sue, hoc speciatim fine a nobis examinatis, neque supra medullosam taeniolam, neque in fossula, neque demum in substantia conarii vestigium vel remotissimum detegebamus.—*Ibid. p.* 165.

‡ Lapilli in conario Simiarum non occurrunt, nam in omnibus a me examinatis Simiarum cerebris, ne ullum quidem acervuli vestigium in substantia conarii detexi; et in reliquis mammalibus, in quorum cerebrum inquisivimus, defuerunt.—*Icones Cerebri Simiarum, &c. p.* 51.

latter acknowledges that they are often wanting in man, though the gland is always found.*

The conclusion of the Wenzels seems, therefore, quite unwarranted, that the pineal gland is an organ for secreting these concretions.

According to Soemmerring, these concretions appear at fifteen years of age; according to the Wenzels, at an earlier period.†

These calculi are small, round, having a rough surface dotted with points, very hard, of siliceous aspect, transparent, and varying much in number and disposition. The larger ones are the result of the agglomeration of several small ones. They are generally collected into a small quadrilateral mass near to the posterior commissure; but at other times, they are irregularly distributed on the sides, or in the substance of the organ—a fact by no means in favour of their being necessary and healthy formations. The Wenzels supposed they had discovered a proper membrane which connects them together.

* Quemadmodum igitur acervulus inde a nativitate ad summam usque hominis aetatem conspicue potest existere, et plerisque in hominibus revera existit: ita etiam quovis vitae anno in individuis deesse potest, quod vel accuratissimae ac diligentissimae peritissimorum anatomicorum disquisitiones comprobabunt.—*Lib. cit. p.* 156.

† Veros ergo lapillos jam septimo vitae anno conspeximus; at in aetate longe minori eodem loco observata a nobis est materia quaedam, acervulo quam maxime affinis, aut potius, si colorem atque consistentiam excipiamus, nihil prorsus ab ipso differre visa.—*Ibid. p.* 155.

Finally, as observed by Soemmerring, the pineal gland is often found turgid with water.* As observed by the Wenzels, the generation and congestion of water, and induration, are its most frequent diseases.† Accordingly, the latter writers justly observe, that the conjecture of Morgagni is probably not without foundation "that these calculi are gradual concretions of earthy particles, their water being by degrees carried away."‡ J. F. Meckel says they arise doubtless from stagnant lymph.|| And this is confirmed by Soemmerring's statement, that Hermbstädt found them to be similar in nature to urinary calculi.§

From all that precedes, then, the final conclusion seems warranted, that that which is absorbed by the vessels connected with this gland, whether they be those of the middle mem-

* Nonnunquam aqua collecta turget.—*De Corporis Humani Fabrica, T.* iv. *p.* 63.

† Observationes istas non levis momenti esse, nemo negaverit: docent enim nos, generationem et congestionem aquae in conario, atque indurationem ipsius frequentissimos ejusdem morbos esse.—*Lib. cit. p.* 154.

‡ Ideoque Morgagni conjectura: "Calculos esse, qui paulatim ex terreis illius particulis, aqueis sensim absumtis, concreverint," forsan fundamento non caret.—*Ibid. p.* 160.

|| Sine dubio a stagnante lympha.—*Observationes Anatomicae de Glandula Pineali.*

§ Auctore Hermbstädt in litteris ad me datis acervulus ossium terra non componitur, sed potius ad calculi vesicae naturam accedit.—*Lib. cit. p.* 64.

brane or more immediately its own, is the vapour or liquid of the ventricles.

The relation of the pineal gland to the terminations of the optic tracks is also as remarkable, as that of the pituitary gland to the beginning of these tracks; for both its anterior and posterior filaments are connected with their expansions.

Awaking, we know, is usually as much connected with the opening of the eyes, as sleep is with their closure; and as awaking, though instantly followed by voluntary acts, is itself involuntary, it is probably on this account that both the terminations of the optic tracks and the white filaments to the pineal gland, are, at the upper tubercles, so intimately connected with the involuntary bundles.

In magnitude, it differs in the different classes of animals.

In fishes, it is scarcely apparent, and is seated deep between the middle lobes and the tubercles.

Carus says that, in some fishes, as the salmon, he found an additional appendage behind the pituitary gland, smaller, more vascular, and, as is sometimes the case with the pineal gland in the higher classes of animals, connected to the brain by vessels only; and Mr. Gore observes that, according to M. Serres, it exists in fishes as well as in all other vertebral animals, though so small in osseous fishes, and so deeply situated between the cerebral hemispheres and the optic

tubercles, that it is distinguishable only by the assistance of a magnifying glass in a good light: he could not discover it in rays; and in all cases its discovery is rendered still more difficult by the manner in which it is imbedded in the vascular and gelatinous matter covering the surface of the encephalon.

Reptiles, Tiedemann says, possess it: at least he has observed it in the hawk's-bill tortoise, wall lizard, and ringed snake. Carus indeed states that a small pineal gland is always found on the ganglia of the hemispheres of reptiles; and that in the frog and salamander, it is of a bright red colour, and in the iguana is closely attached to the cerebral veins.

In birds, it is found consisting sometimes of several portions, as in the pigeon, though it is generally solid and conical.

In some mammalia, say the Wenzels, it is absolutely, in others proportionally to the bulk of brain, larger than in man;* and Tiedemann remarks that its volume is much more considerable, in proportion to that of the brain, in the ruminantia than in man.

The pineal gland according to the same writer, was not perceptible in the brain of fœtuses two and three months old, nor did he recognise it

* Diversis in mammalibus absolute, in aliis vero proportionate ad magnitudinem cerebri magis, quam in humano cerebro insignis est.—*Lib. cit. p.* 90.

until the fourth, when it appeared in the form of a small and flat body, the pedicles of which, extremely delicate, arose from the internal border of the superior surface of the posterior striated bodies. It gradually augmented in volume during the course of the following months, but always continued round and flat. Its tissue was so soft as to prevent the examination of its structure.*

Soemmerring observes, that the pineal gland is largest in the brain of women;† and this entirely conforms with my view of its functions.

In relation to nervous parts, Soemmerring observes that, at its anterior inferior part, it is, by its transverse white bundle above the posterior commissure, connected with the posterior striated bodies, with the anterior tubercles, and with the posterior commissure.

Anteriorly, in all mammalia, the pineal gland is always connected with the posterior striated bodies by means of two pedicles, which ascend from the pisiform eminences.

According to the Wenzels, however, these pedicles receive filaments as they run backward

* Conarium embryonis quinque mensium, say the Wenzels, subtilis acus capitulum magnitudine aequans, rotundum, ac ex pallido cinereum est.—*Ibid. p.* 149.

† Nonnunquam in maiori cerebro maius adest, nonnunquam in minori cerebro minus: maximum est in cerebro feminarum.—*Lib. cit. p.* 63.

over the posterior striated bodies,* where they form a slight prominence, gradually increase in bulk, pass over the sides of the posterior aperture of the ventricle, and unite before giving off the fibres which attach them to the gland.

The pedicles of the pineal gland seem generally to be much larger in mammalia than in man.† They are larger also in the adult than in the fœtus.‡

As these pedicles are thus connected with the pisiform eminences and the arch, it is not improbable that thus the functions of this gland affect or are affected by the involuntary reflexions.

Posteriorly, the pineal gland is not only similarly connected with the tubercles, but it rests

* Ea, in nonnullis saltem mammalibus, quibus cervus cum sue accensendus est, pluribus perspicue invicem disjunctis portionibus, sive medullaribus fasciculis, ex medullari colliculum opticum obducente lamina oritur. Medullaris videlicet substantia, inferiori membranae istius faciei adhaerens, taeniam versus pluribus, et quidem in sue tribus locis concentrari, densior et magis alba reddi, atque sic in taeniam transire, sive potius eandem formare videtur.—*Lib. cit. p.* 90.

† Medullarem taeniam, sive medullarem striam in interiori superiorique margine colliculi optici in cervo, ove, cuniculo, sciuro et fele valde insignem, quinimo, habita ratione multo insigniorem, quam in homine reperimus.—*Ibid. p.* 89.

‡ In recens natis infantibus adhuc ferme plana, in adultioribus eminentior, saepe valde prominens et revera taeniae formam exhibens.—*Ibid. p.* 87.

on those organs of the involuntary muscular system. It apparently bears the same relation to that system, as the pituitary gland does to the vital. As sleep depends on the relative predominance of the vital system; so apparently does awaking on that of the involuntary muscular.

Let us now connect these views with the state of the brain and of the ventricles.

It seems probable that the nervous matter is actually wasted during muscular and other excitement. This, I suspect, takes place to much greater extent than is commonly imagined. And it appears to be owing to this waste that sleep follows great muscular exertion.

When the muscles are fatigued, the senses are obviously enfeebled, and those which are kept open by means of muscles, gradually close. In sleep, sight becomes first dormant, next taste, then smell, afterwards hearing, and lastly touch.

Sleep supervenes, in order that the nervous system may be repaired by the vital. Waking is the period of expenditure; sleep, of assimilation. The nervous system, therefore, must rest, while the vital supplies it with new materials.

Sleep is consequently connected with the deposition of new cerebral matter, and the nervous functions are thereby recruited.

In sleep, the pulse becomes slower, but more full; the respirations are less frequent, but

deeper; the blood is more decidedly propelled to the internal capillaries; and their functions are performed with more freedom and force.

It would not be wonderful if, under these circumstances, the growth of the body, as has been asserted, were effected chiefly during sleep, or if the healing of wounds were then more rapid.

It was in this sense, perhaps, that Hippocrates observed that, during sleep, the motions tend from the circumference to the centre; and, as the tendency to sleep is encreased by the inactivity of the nervous system, there can be little doubt that, when the power of the nervous system abates, the unimpaired vital system begins to exhale vapour or to throw water into the ventricles, the sides of which no longer resist its influx, so that sleep ensues.

The Wenzels throw much light on this view of the subject, in the following observations.

"On the 29th of May, 1801, at Mentz, four persons guilty of capital crimes were decapitated by means of the guillotine.

"Thirty-five minutes after the decapitation of the last, the body of him who had first suffered, was brought to Ackermann, professor of anatomy, together with the four heads, of which three were immediately opened, and the brains subjected to examination.

"On examining the brain of him who suffered last, we found, in the descending and posterior

horns of the left lateral ventricle, a little lymph; but in the right lateral and in the fourth and fifth ventricles* (we could detect no ventricle in the thin partition), there appeared no vestige of any liquid.

"In all the ventricles of the brain of the second, we saw not even a drop of liquid.

"The condition of the third brain was the same as that of the first. At the same time, however, there was here lymph in many places between the middle and inner membranes of the brain.

"In the pericardium of him who was first decapitated, we similarly observed lymph.

"The brain of the fourth was examined on the morning of the 30th of May, about fifteen hours after punishment and death.

"In the ventricle of the middle partition, in the left lateral, and in the fifth ventricle, there was lymph, in general more plentiful than in the first and third brain.

"These observations teach us that, in brains examined immediately after death, where nearly the natural heat of the body still remains, the liquid of the ventricles exists in the same manner, as in brains of which the examination is instituted at a later period: the liquid, namely, is sometimes present, sometimes

* The 4th and 5th ventricles of the Wenzels, are the 3rd and 4th of other authors.

absent; but if it be present, there seems to be no other reason of its presence, than there is of the presence of the humour of the pericardium and of that which is found between the membranes of the brain, for of both, the nature, condition and purpose appear to be the same, it seems to appear in a kind of aqueous humour only in consequence of the circulation being altogether terminated and the functions of the absorbent vessels nearly extinguished after death, whereas, had life remained, it would have escaped observation as a subtile vapour."*

* Die vigesima nona Maji 1801, Moguntiae quatuor criminum capitalium rei securi a Guillotin dicta capite plexi sunt.

Triginta quinque post ultimi supplicium minutis, Professori anatomiae Ackermann, cadaver illius, qui primus poenam subierat, afferebatur una cum quatuor capitibus, quorum tria confestim aperta sunt, et cerebra examini subjecta.

Cerebrum postremo judicati explorantes, in descendente ac posteriore cornu sinistri ventriculi lateralis paululum lymphae reperiebamus; in dextro autem laterali et in quarto ac quinto ventriculo (ventriculum in septo cerebri medio non poteramus detegere) nullum adparebat humoris alicujus vestigium.

In omnibus cerebri ventriculis secundi, liquoris ne guttam quidem conspiciebamus.

Tertii cerebri eadem, quae primi, erat conditio. Simul autem etiam hic arachnoideam inter et vasculosam cerebri, lympha pluribus locis aderat.

In ejus, qui primus interfectus fuerat, pericardio pariter lympham animadvertebamus.

Quarti cerebrum trigesima die Maji tempore matutino, quindecim circiter post poenam mortemque horis, examinatum fuit.

This conclusion is not quite accurately drawn; for, on one hand, the quantity of liquid appears to have encreased with the lapse of time between decapitation and opening the head; and, on the other, it by no means follows that during life no liquid would have existed. The legitimate conclusion in this case seems to be, that in the brains of persons thus subjected to intense activity, the liquid of the ventricles is found in unusually small quantity or is altogether absent, because, conformably with the views given both in this and the preceding section, the sides of these organs of consciousness were, during their immediately previous excitement, in closer contact than usual, and because there was then less disposition to throw into them their vapour or

In ventriculo septi cerebri medii, in sinistro tricorni et quinto ventriculo lympha erat, generaliter copiosior, quam in primo et tertio cerebro.

Observationes istae docent, in cerebris statim post mortem, ubi naturalis corporis calor ferme adhuc existit, examinatis, praesentiam humoris ventriculorum eadem ratione se habere, ac in cerebris, quorum examen serius demum instituitur: humor videlicet quandoque adest, quandoque desideratur; si autem adest, praesentiae ipsius non alia videtur esse ratio, quam quae est cum praesentia humoris pericardii, et ejus, qui inter cerebri membranas invenitur, hujus enim aeque ac illius eadem natura, conditio et finis esse videtur, et solummodo per circulationem omnino sublatam et ferme extinctas vasorum absorbentium functiones post mortem, specie aquosi humoris videtur adparere, cum, vita superstite, tamquam subtilis vapor oculi aciem fugiat.—*Lib. cit. p.* 199.

liquid, and that the same indisposition attends the state of parts after death; but that, under other circumstances, they either are capable of throwing out a liquid, or their vapour readily condenses so as to produce the quantity of liquid which we almost always find in the ventricles. Now, as, conformably also with these views, this liquid appears to be thrown out, or this vapour condensed, when the activity of the system is diminished, it seems by no means improbable that this occurs during sleep and various conditions of the system, and that it is only an excess of this tendency which constitutes disease.

In conformity with this view, M. Magendie says, that the liquid of the ventricles is very abundant in idiots and persons of weak intellect, and, on the contrary, in small quantity in those whose intellectual faculties are active and fully developed: hence he thinks the quantity of liquid is in an inverse ratio to the development of the mental faculties.

But whether water is secreted or vapour is exhaled into the ventricles, is immaterial in relation to the doctrine here delivered, which assumes only more or less of distension. That one or the other takes place, is evident from the separation of the sides forming these cavities; for this nowhere takes place except for the purpose of permitting the motion of parts which, like the viscera, are comparatively free and loose

in their cavities, and that is not the case in the brain, or for the purpose of exhalation or secretion—the portion of the alternative which must therefore exclusively apply in the present case. This argument is of itself decisive; but it is enforced by the existence of the vascular apparatus of the ventricles, of the water generally found in them, of the phenomena attending its excessive accumulation in disease, &c.

Now every consideration, philosophical and practical, even the cases above recorded by the Wenzels, tend to prove that it is not during the highest activity of the mental system that such exhalation or secretion takes place, but on the contrary when its quiescence has supervened. Correspondingly, we know that sleep is impossible under any strong excitement of the mental system.

Thus it appears that, on the cerebral cavities or ventricles, in which white fibres from all parts of the brain are spread out so as to come into the most extensive and delicate contact, depends consciousness, or the cognizance which each great organ of the brain has of another's motion —and sleep, when, by the accumulation of the water or vapour of the ventricles, these parts are not in contact.

It has not, I believe, been observed, that the senses which we have no power of closing, are precisely those which are most useful during

sleep—smell, namely, which respiration at all times requires, and hearing, of which darkness does not impair the function, while the stillness of night (the natural period of sleep) facilitates its exercise. On the other hand, the organs of taste and vision, which would then be useless, are generally closed.

Dreams are probably caused by certain portions of the brain continuing awake, while others are asleep.

In sleep-walking, the conscious and voluntary functions appear to be dormant; the unconscious and involuntary functions awake; and in conformity with the preceding doctrine, the absence of water in the fourth ventricle is probably a condition of sleep-walking.

The duration of sleep is generally a third of the day. This proportion I find absolutely necessary, in my own case, to the effective prosecution of any delicate or difficult enquiry. For such enquiry, a shorter period of sleep not only incapacitates me during the following day, but even during the subsequent one, unless I proportionally extend the time of sleep during the intervening night. I believe others will observe the same effects, if they attend as closely to them. He therefore who thinks he can dissipate his time at night, and yet study during the day, deceives himself, or means to deceive others when he says so in apology for irregular

habits. There are few acts more cruel than depriving dependent persons of their due proportion of sleep.—Children sleep more in proportion than elderly persons.

We awake probably because the new deposition of nervous matter gives preponderance and elasticity to the nervous system, and the power of rapidly or strongly conveying impressions which must again bring into contact the sides of the ventricles.

This is doubtless aided by exciting causes, of which some are internal and others external. Of the former kind, are accumulated urine, excrements, and other excretions; of the latter kind, every thing that can stimulate the senses.

The most remarkable circumstance in the history of sleep is this, that it also would seem to be under the power of volition; and that, in order to awake at any hour, it is only necessary to determine to do so.

It appears to me that our awaking at or near to a time resolved on, depends greatly, if not entirely, on this, that it shall have been *our last resolve on going to bed;* that it has consequently left *the deepest trace in the memory;* and that, accordingly, *that trace must first recur,* in partially awaking, the slightest impression associating with it.

SECTION IX.

STRUCTURE AND FUNCTION OF THE FREE EXPANSIONS IN VENTRICLES—THE THIN PARTITION, ETC.

In describing these complex parts, I shall as far as possible follow the views of Reil, both in order to increase the reader's confidence in the data presented to him for physiological induction, and in order again to point out the confusion which ensues from want of method, or, as is here the case, from the adoption of opposite methods, and the necessity of rectifying this before any physiological conclusion can be drawn. I need scarcely repeat that a simple description would be far more easy than this critical procedure: but Reil's authority as to facts, and the warning which his example holds out as to method, are too valuable to be thrown away.

Of the thin partition, then, or free cerebral expansion, as I think it might be called, Reil states that it is interposed between the lateral ventricles, and is formed by the reflection of two layers of the lining membrane, the epithelium, one derived from either of the cavities, which it assists in separating; that it has an ill-defined, triangular margin, bounded by curved lines; that its inferior angle reaches to the anterior commissure, where it lies exposed between the

anterior peduncles of the arch and the fillets of the perforated plate; that its apex is found between the arch and the anterior commissure, in the vicinity of the lyre; and that its third and rounded angle is at the concave surface of the anterior fold of the great commissure.

Considering this body as a centre, and describing first the parts most closely connected with it, he observes, that the base of the triangle is short, the under concave margin, and the upper convex one, forming the longest sides; that, at the fore part, it begins by the meeting of either layer of epithelium upon the anterior commissure; that the base of the triangle, above supposed, is formed by an extension [upward] of the partition from this point to the bend of the great commissure, and corresponds with a linear furrow, which is seen on the base of the brain between the fillets of the perforated plate [here he proceeds from below upward; but immediately reversing that order, he states] that from the posterior extremity of this furrow, which immediately touches the anterior commissure, a delicate membrane extends to the commissure of the optic tracks, thus completing the base of the brain anteriorly; and that, from this linear furrow, the duplicature of the partition may be unfolded, and the division of the brain into two similar lateral portions effected.

Elsewhere, taking points generally external

to these, he observes, that the anterior fold of the great commissure ends with a distinct concave margin, a full quarter of an inch before the anterior commissure; that, from this margin, a furrow extends backward, either half of which results from a reflection of the epithelium, which invests the anterior horn of the lateral ventricle, and assists in forming the thin partition, and that a rent from this furrow, therefore, would split the base of the partition; [so far he proceeds from above downward; but immediately reversing that order, he states] that, along either margin of the furrow belonging to the superior commissure, a white band, continuous with the medulla incognita, is seen to extend to the edge of the anterior fold of the commissure, at which point a blind hole exists; that these two white bands are the fillets of the perforated plate; that white bundles are generally observed to be derived from them, which in most cases plunge in by the blind hole, and lose themselves in the thin partition, but sometimes are continued along the convex surface of the anterior fold of the commissure; [here he proceeds from below upward; but, immediately reversing that order, he states], that a thin layer of nervous matter is continued from the furrow and posterior margins of the fillets, to the commissure of the optic track, closing the third ventricle at the

fore part; and that the concave extremity of the anterior fold, the fillets, the perforated plate, and the grey matter of the inner and inferior convolutions of the anterior lobes are reciprocally continuous.

These accurate, but detached and irregular, views, give a good idea of the parts immediately connected with the thin partition; but I do not hesitate to say that this very detached and irregular procedure was absolutely hostile to Reil's peculiar method of tracing fibres, and often prevented his doing so to any considerable extent. In the present case, it probably diverted his attention from the more remote origin of the thin partition, in the perforated plate of Meckel. Here we must follow a more direct and brief procedure; for a continuation of the preceding critical one would occupy too much space and time.

The perforated plate is formed of a particular substance; and although its fibres seem to be white, yet they approach to those of the other description.

This plate comes from the external portion of the anterior striated body, where it seems to contribute to form the inferior wall of Reil's capsule.

It is thus in contact with the system of the peduncles; and it may thence receive fibrils from nerves of touch.

It is, there, moreover, in the neighbourhood of the lateral expansions, which are probably connected with taste and hearing.

These remarks are made, because, in other situations, this plate appears to be much connected with, if it be not composed by, the terminations of sensitive nerves.

It then runs forward between the optic track, the anterior commissure, and the external root of the olfactory nerve; and it is remarkable that, in passing forward to the optic commissure, it takes the same curve with the optic track.

The optic nerves, from the upper part of their commissure, then send numerous filaments to the perforated plate. Vicq d'Azyr shows well the grey plate ascending from the junction of the optic nerves, which shuts the third ventricle anteriorly, and extends toward the anterior commissure; but he first speaks of it as thence descending to the junction, and then mentions its striæ as running upward, and the most external, outward. He afterwards justly remarks what no one seems to have attended to, that distinct fibres of this plate blend with the tissue of these nerves of which they ought to be regarded as a particular origin [termination].

Filaments of the internal root of the olfactory nerve may also be traced very nearly to the perforated plate; so that it seems to be composed

of filaments from the terminations of some of the chief nerves of sensation.

The perforated plate then contracts, bends over the anterior commissure, ascends by the great fissure dividing the anterior lobes, passes behind the beak of the great commissure; and having previously united to some portion of the grey tubercle at the bottom of the third ventricle, expands into a plate sufficiently extensive to be adapted before to the concavity of the great commissure and behind to the convexity of the anterior pillars of the arch, as has been already described.

Thus the perforated plate appears to collect fibrils from some of the more important nerves of sense to carry them to the thin partition.

Of the structure of this organ, I have only further to remind the reader, that between its layers is a ventricle, lined with its proper epithelium; that this cavity is from a line to a line and a half in breadth anteriorly, and narrows to a point posteriorly, where it terminates above the lyre of the great commissure; that in the fœtal brain, it communicates with the third ventricle posteriorly, by a small triangular opening between the anterior pillars of the arch and the anterior commissure; and that this communication is sometimes found open in the adult.

The ventricle of the partition being larger in the fœtus than in the adult already indicates

that it is *one of the portions first necessary in the perceptive system;* and the observation of the Wenzels, that, in quadrupeds, it seems to have the same proportion as in man to the magnitude of the brain and to the length of the superior commissure, corroborates this view of its primary necessity. This may indeed well exist, as it receives the first and shortest terminations of some at least of the sensitive nerves.

Expansions similar to this are also found between the tubercles and cerebel, and between certain parts of the cerebel posteriorly.

Thus, behind the posterior tubercles is formed an expansion, which adheres to the inner edge of either anterior cerebellic peduncle; and, opposite to it, but behind the cerebel, is situated another, which has a middle portion attached to the nodule, and two free semilunar portions attached to the small body called the flock on either side.

The former, says Tiedemann, exists in all mammiferous animals; but the latter does not present the same regularity: in the hare, rabbit, beaver, &c. it is merely indicated by a prominent line or margin; and, in the sheep, ox, dog, cat, horse, &c., it forms a small membrane, slightly connected to the appendages of the flocks.

With regard to the anterior or tubercular expansion, Reil states that, between the bodies of either anterior peduncle of the cerebel, is the anterior expansion, consisting of fibres parallel

with those of the peduncles; that either of its surfaces is covered with epithelium; that the upper surface is sometimes, at an early period, white, but is, in most instances, covered with a transversely furrowed layer of grey matter; that in the latter case, the first lobule of the superior vermiform process is in some manner continuous with the expansion; and that a small process extends some way upon the expansion, derived from the centre of the posterior tubercles.

These facts are important as showing more particularly, what is indicated generally by its situation, namely, that the anterior expansion belongs rather to the tubercles than to the cerebel; for it is evidently connected with the former; and we know that the course of the fibres and of the action of these parts is from the tubercles toward the cerebel: such we have seen to be the case with the peduncles which support this membrane. We might, therefore, suppose that it bears the same relation to the tubercles and (as in the sequel will be seen) to involuntary nerves, that the thin partition bears to the more important nerves of sensation. We accordingly find the internal oculo-muscular which is perhaps altogether an involuntary nerve, and the general oculo-muscular and trifacial which are more or less so—that is, all the nerves between the brain and cerebel, either evidently attached to it, as the former, or approaching closely to it, as the latter.

It is also certain that, from the median furrow of the fourth ventricle, delicate white bundles emerge, probably the terminations of the lower involuntary nerves, which attach themselves to the inner margin of the superior peduncles.

The posterior expansion, Reil divides into a middle slenderer and attached portion, and two lateral free and semilunar portions; and states that, of the two lateral portions, the substance is white, the structure membraniform, the epithelium that common to the fourth ventricle, the form semilunar, the convex margin adherent, the concave edge turned forward and unattached, so that it is easy to introduce a probe above either of them, and to carry it round its convex attached circumference;—that their outer extremities are attached to the internal sharp margin of the flocks, and pass along these bodies to the point at which their first plates are given off;—that from either outer extremity, the fixed and convex margin may be traced backward to the root of the almond-like lobes; being adherent during the first half of this passage to the restiform bodies; that thence the convex margin passes under the anterior peduncles, being attached all the way to a roller-like elevation of white matter, which surrounds the posterior margin of the semiglobular cavity there formed; that, in its approach to the white lateral surface of the spigot and nodule [small mesial

prominences behind the pyramid], the convex and attached margin of the expansion is inclined forward and downward; and that it then coalesces with the white stem of these parts;—that the unattached margin of the lateral portion of the expansion passes from side to side across the semiglobular cavity formed by the contiguous parts, and below the anterior and posterior peduncles; and that the upper surface lies unadherent in that cavity, while the rounded extremity of the almond-like lobe rests upon the under; that near its attachment to the nodule, the inner extremity of either lateral portion of the expansion is split into two plates; that the posterior loses itself in the lateral white matter of the nodule; that the anterior, which is from two to two and a half lines broad, passes across the fore part of the nodule, adhering to it by its posterior surface; and that its anterior surface looks to the fourth ventricle;—that this is the central portion of the posterior expansion; the upper and posterior margin of which joins, at an acute angle, the anterior expansion immediately below the vertical process of the central commissure; the anterior expansion being adherent to the white matter of the vertical process for a short extent before its union with the posterior.

Reil then asks, "for what object are these white expansions intended? Both have an attachment to the same parts; both are of the same

construction; both probably agree in function: one point is evident, that the posterior expansion is in relation with the inferior portion of the cerebel."

Now it appears to me that his own subsequent description of the flock indicates the reply to the question. He observes that either flock seems to be the germ of an ill-developed lobe; that the nodule may be their commissural portion; and that the union of this to the flocks is effected by the lateral portions of the expansion;—that the stem of the flock divides into two roots, one of which passes round the posterior margin of the semiglobular cavity to the pyramid, and the other transversely across the posterior peduncle to the central depression in the floor of the fourth ventricle; and that between the two, the outer corner of the lateral portion of the posterior expansion joins the stem of the flock.

The vicinity of all these parts to the organ of hearing is remarkable. This expansion traverses the ventricle nearly parallel to the roots of the auditory nerve, and may easily receive fibres from it; while the relation of the flock in this respect is very strongly indicated by its connexion, like the auditory nerve, with the floor of the fourth ventricle, and by the circumstance that, in birds and mammalia, its greater portion is lodged in a peculiar depression of the petrous portion of the temporal bone between two of the

semicircular canals. It is found so situated even in the fœtus, but in the adult it recedes from it, as that portion of the bone is filled up.

It seems, therefore, not improbable that as nerves connected with perception send terminations to the thin partition or cerebral expansion, and nerves connected with involuntary action to the tubercular expansion, so nerves connected with voluntary action send terminations to the cerebellic expansion. Thus these expansions generally may apparently be regarded as receiving the first and most direct terminations of the encephalic nerves.

The function of these expansions must accordingly be merely to receive successive perceptions, of which we are conscious, as all these expansions are exposed in the ventricles. As, however, the successive actions transmitted to these parts are instantaneous, as each probably obliterates its predecessor, and as they must precede the impressions of memory, and the subsequent combination of perceptions, they probably compose not ideas but the mere first perceptions of external objects; and that, in the very first instance, we receive and contemplate these *distinctly*, consciousness seems to attest.

Now, simple as this first operation is, it seems to be the great material that sensation affords — the element of every other operation that takes place in the mind; and consequently all other

mental operations must consist either of perceptions combined with each other, influenced by the will, or modified by the conditions of other systems.

I have treated of these expansions last, instead of first among the superadded organs, as the instantaneousness of any action taking place in them, their priority and their simplicity would seem to require, and I have not insisted on my conclusions respecting them, but considered these only as probable, because since the general reception by them of the first terminations of nerves has struck me, I have not been able to procure a brain for the purpose of more extensively verifying the circumstance. The indications however, are so strong, that I feel satisfied of the result.

SECTION X.

MODE IN WHICH THE SIMPLE FUNCTIONS PRODUCE THE MORE COMPOUND ONES.

In this and the preceding sections, I embarrass myself with none of the common doctrines of "the philosophy of the mind." Those who have written works with this title have never known anything of the structure of the brain; and they might just as well have written about the philosophy of the steam engine, without the slightest knowledge of mechanics! Des-

cartes appears to have been aware of this. This domain, indeed, is that of the physiologist and of the medical philosopher alone; and if the latter cultivate it duly, it will do more to raise his character than all he has hitherto achieved. It is a domain, however, on which he must not suffer the ignorant and unqualified to trespass. In that domain, the so called moral philosopher is a mere poacher, and may easily be convicted whenever he is caught. He has not one requisite qualification, and may be said to carry only a forged certificate in his pocket.

From what has now been said, it seems probable that the first function performed in the brain is that described in the last section. From that, it would appear that the first and shortest terminations of sensitive nerves, or of the sensitive portions of compound nerves, run directly to the free medullary expansions; in which it seems probable that the action of an organ of sense, being merely repeated in the common sensorium, and accompanied by consciousness, first becomes perception.

It is evident, however, that something else must take place in the brain before any foundation can exist for the higher processes. We, accordingly, find that, by a longer traject, other terminations of the same sensitive nerves, at the same moment impressed, pass to the convolutions, forming a great terminal and expanded

organ, and there leave those impressions on which memory depends. Thus, not only the existence of perceptions, but the connexion of them with past ones of the same description, precede the formation of ideas; and consciousness tells us that precisely such existence and memory of distinct perceptions are necessary to every clear and definite idea.

The interconvolutional bundles, connecting, in a thousand ways, the parts of the last mentioned organ throughout its vast extent, next present the means, and we are, often, if not always, conscious of the act, of associating past but different impressions, with present ones. These associations, as we know, may be similar, contrasted, &c.; and, whatever they are, they always tend to encrease the distinctness of the idea we are forming. This precession of association, as well as of memory, is obviously useful, if not essential, in the formation of distinct ideas.

Thus, rapid though the process is, it is only after the triple operation of receiving perceptions, of remembering, and of associating—that is after obtaining the most perfect knowledge of perceptions in their distinct state, that, by the great centralizing organ, the commissure, we combine them in a complete idea. And as the organ of accomplishing this is the mere continuation of the dispersed fibres of the preceding organs, now strongly and rapidly converging, it

seems impossible to contemplate this, without seeing the necessity, as well as feeling conscious of the truth of this function. The conclusion, too, is obvious, that, rapid as this process is, it is thus capable of the greatest accuracy.

But the returning or descending cerebral bundles which also converge, though less conspicuously, from the convolutions, have, during the last described operation, carried a share of these motions toward the posterior striated bodies, whence they may proceed separately, but may also be joined by the sheets thither descending from the commissure. Speedily, therefore, by an involuntary reflective process—the function of the cerebral arch, commencing just before the cerebral action had reached the organ of will, and, after a circuitous course, terminating near where it usually begins, the past perceptions are compared with now present ones; and as, in their long transit, they are associated with the state and the wants of the vital system, pleasure or pain is superadded to the idea which they form, and which consequently becomes an emotion. And here, as before, consciousness confirms this truth. It is evident, too, that the production of emotion is enforced by important branches of the nerves of sight and smell — senses of relation directly producing emotion, terminating precisely where the cerebral arch begins.

Cerebral action now has not only been reinforced by accumulated perceptions, but, with the idea which these form, has been associated a relation to the vital system and its wants, which, adding pleasure or pain to the idea, they compose an emotion; and, the great cerebral organs being thus occupied, we might naturally expect an extension of their action to the cerebel, the physical means of which have been explained. An appeal to consciousness corroborates this view; for it tells us that to pleasure or pain as naturally succeeds desire or aversion, the function of the organ of will. The organ of will must, as we have seen, by means of its descending annular masses re-act upon the brain, and by adding desire or aversion, to pleasure or pain, must convert the emotion to passion. This conversion is evidently enforced by important branches of the nerves of hearing and taste—senses of motion directly producing passion, terminating precisely where the cerebellic ring begins.

Of the localities of the three latter functions, of combining, comparing and determining, it may be observed—that the combining faculties are connected chiefly with the anterior superior part of the brain, in which two-thirds of the great commissure is placed and where the expansion, from the peduncles, of the nerves of touch, the sense belonging to pure objects, ob-

jects as they are in themselves, is least associated with the nerves of sight, hearing, &c. which send great branches to the middle and posterior part of the brain;—that the comparing faculties are connected chiefly with the middle and inferior part of the brain, in which the arch is entirely placed, and whither the nerves of sight and smell the senses belonging to relations, in a great measure pass;—and that the determining faculties are connected chiefly with the posterior part of the brain and the cerebel, whither the nerves of hearing and taste, the senses belonging to motions, chiefly pass.*

Of the natural succession of these faculties, it may be observed,—that combining, dependent on the anterior part of the brain, should evidently, as it does, succeed sensation and perception, because it is immediately derived from them;—that comparing, dependent on the middle part of the brain, should as evidently succeed observing, because it can thence alone derive its means;—that determining, dependent on the posterior part of the brain, should not less evidently succeed comparing, because it can be founded on that alone;—and that volition, dependent on the cerebel, should evidently, as it

* The portions of the brain in which the nerves of other senses terminate, combine as well as this does, but they are successively connected with the addition of new faculties, and are thence classed. It is these successive additions which enlarge the brain posteriorly and give it its peculiar form.

does, succeed determining, and influence muscular motion.

The results of combining as we have seen, are ideas : the results of comparing are emotions : the results of determining are passions, or, more simply considered, desire or aversion.

Consciousness accompanies the whole of these operations.

It is scarcely necessary to illustrate these simplest operations of the mind by examples. This may be done, however, from a correspondingly simple object. If an orange were laid before any one, he would have distinct perceptions of form, colour, smell, &c. ;—each of these would be instantaneously remembered, if it had previously impressed the organ ;—the whole would quickly be combined in an idea or image of the object ;—it would next be involuntarily referred to the wants of the vital system, and pleasure or pain being added to the idea, it would thus become an emotion ; — the will would then be called into action, and desire or aversion, being superadded to the emotion, it would become a passion ;—volition would finally excite the muscles, and the orange would perhaps be grasped by the hand.

In this and in every case of the activity of the mental functions, it is obvious that this succession and combination may be more or less varied. They are here described in such succes-

sion as appears to be at once the most usual, and to indicate their natural dependence.

To each of these processes, then, a corresponding organization exists in the internal part of the brain; but I can discover no vestige of any, for the thirty or forty little functions of the craniologists.

It seems to be in connexion with these earliest and simplest operations that what is called intuitive evidence should be mentioned, as its two species belong respectively to perception and consciousness. These are:—

1. The evidence of the external world.—This is variable, owing to the variableness of the senses through which it is acquired; and it was the ascription of this variableness to matter itself that laid the foundation of the system and of the erroneous conclusions of Berkeley, as I long ago showed. The variableness of the senses, however, is inseparable from our organization; and it is only mistake that can here lead to wrong conclusion.

2. The evidence of internal consciousness.—This is as infallible as the preceding, and if it seem more difficult to follow in its details, that is owing to the almost universal neglect and want of practice in retracing mental operations. This I believe to be the most improving practice in which the mind can engage, and the best preparative for its most delicate operations.

It will be observed that the functions already described are far more simple in their nature than they are generally represented to be; and I am quite satisfied that it is the neglect to proceed thus that has always embarrassed mental physiology. Each of these functions, however, has become successively and gradually more complicated. They all admit of yet further complications; and all of these complications appear to be produced by the subjection, in a greater or less degree, of perception and its effects to the will—by the voluntary direction or determination of mental operations, of which the last described organ, the cerebellic ring, is the means.

When perception is placed under the guidance of the will, it constitutes attention.

Dugald Stewart observes, that it appears from the acquired perceptions of sight, that a process of thought may be carried on by the mind, without leaving any trace in the memory; and many facts prove, that impressions may be made on our organs of sense, and yet be forgotten next moment. In such cases, our want of recollection is ascribed, even in ordinary conversation, to a want of attention; so that it seems to be a principle sufficiently ascertained by common experience, that there is a certain *act* or *exertion* of the mind, necessary to fix in

the memory, the thoughts and the perceptions of which we are conscious. This act is one of the simplest of all our intellectual operations, and yet it has been very little noticed by writers on pneumatology.

As relating to this subject, I may here observe that owing to the variety of the apparatus of thought in man, certain disadvantages appear occasionally to arise. The chief of these are probably dependent on the interconvolutional organs and the arch. In consequence of these, when reading, or when hearing others speak during a considerable time, association or involuntary reflexion, the functions of the respective parts referred to, carries us away from the proper subject of our attention. Such distractions will probably be great in proportion to the development of the organs alluded to.

I recollect having perpetual struggles of this kind in attending to lectures when a student. After observing and regretting these distractions, I resolved, at the beginning of each course of lectures which I attended, to hear them through, without having one neglect of that nature to reproach myself with. In this, I sometimes succeeded for months, but never throughout a course. The nonsense which the lecturer sometimes spoke and the scorn it excited, the train of thought which even this nonsense occasionally called up, the more useful conclusions which

sometimes seemed almost within my grasp, if I would but abandon my mind to their pursuit, the idler visions that imagination sometimes supplied, the confusion caused by incessant struggles against all this, often defeated my most determined resolves.

Nothing accordingly seems to me more important than the frequent exercise of the organ of will in its influence over that of perception, &c. Where the latter is of high development and powerful function, such control and guidance appear to me to be the consummation of mental excellence.

When memory is guided by the will, it constitutes recollection or conception.

When association is similarly influenced, it appears to constitute imagination.

In illustration of the last three processes (by the kind of example previously employed), it is evident that, if the will turn the senses and perceptions to the external qualities of the supposed orange, we may become better acquainted with each of these by means of *attention* ;—if such an object had been seldom seen or seen only at some remote period, the will might guide the memory to a more or less perfect *recollection* of it ;—and if the image of the orange were associated with the grove where it grows, the will might carry us, in *imagination*, with Goethe, to the land

"wo die Zitronen blühn,
Im dunkeln Laub die Gold orangen glühn,
Ein sanfter Wind vom blauen Himmel weht,
Die Myrthe still und hoch der Lorbeer steht."

When the process of combining is complicated, it is called understanding: when the process of comparing is complicated, it is called reasoning: when the process of determining is complicated, it is called judging.

We are too apt to mistake these last for the first operations of the mind, when in reality they are preceded by all those already described. It is this mistake, as already observed, that makes mental operations seem far more complicated than they are.

Understanding differs, then, from combining in this, that while the materials of the latter are only simple and distinct perceptions, and ideas are its results, it is these last which are the materials of understanding, and which it employs, either as co-existing or successive.

Thus if we are told that an orange, for certain reasons, is cooling, or that champagne, for certain reasons, is heating, we are presented with the idea of the orange or the champagne, with that of a cooling or heating property, and with those involved in the reasons alluded to, and all these in connexion; for if this were not the case they would only be so many distinct ideas. Here then are not merely several ideas more or

less simple, but they are placed in certain relations to each other. To the knowledge of these relations, the term understanding, in its most limited sense, is applied—they are said to be understood.

It was in reference to this knowledge, not of fact only but of relations, and to the encreased number and complication of these in higher mental processes, that, at the beginning of this work, I made some observations respecting them which these more systematic views will now be found to corroborate.

To collect facts, I then observed, is the first duty of the enquirer; and in doing so, the utmost accuracy is the principal requisite.

"Merely to collect facts, however, is an easy and mindless task, that any common being can perform: it requires eyes and hands, and almost dispenses with a brain: it is the work of a toiling wretch who, like the miser, is incapable of using what he possesses. Mere facts lie around even the savage; but he knows not what he sees. And such, precisely such, is the case with the mere learners of the names of things, the collectors of little facts, the undiscriminating triflers, who think they are cultivating the sciences.

"When, in scientific research, no distinction is made between great and little facts—when no enlarged view is taken of structure—when no analogy is dreamt of—when no forethought of

function exists—the mind is bewildered amidst the multiplication of trifles, no notion of relative importance is acquired, and no great conclusion can be attained."

"When, on the contrary, the greater facts, the largest views of structure, every analogy our knowledge can afford, and every indication of the general course of function, are chiefly thought of, the smaller facts seem almost to arrange themselves, their precise mode of dependence presents itself, and the whole is accurately systematized."

In this mode of procedure there is no room for foolish prepossession: if hypothesis open upon the mind, it is rational hypothesis: thus founded, it hazards no serious error; and true theory is generally its result.

"To collect facts, then, discerning great from little objects, to arrange them in the order of their relations and dependence—I should say, to permit them to arrange themselves, to discover the system pursued by nature, and spread through all things, to render a few facts the means of predicating a thousand,—this is the highest achievement of human genius."

It is here that signs become of the greatest importance to us.

By our perceptive powers, says Stewart, "we are made acquainted only with what is particular or individual; but this description comprehends a very small part of the subjects

about which our thoughts are employed. In by far the greater number of instances, our reasonings relate to classes or genera of objects or of events.

"An appellative, or a generic word is a name applicable in common to a number of individuals, which agree with each other in some particulars, and differ in others. By means of such words, we are enabled to reason concerning classes of objects and classes of events, and to arrive at general conclusions, comprehending under them a multitude of particular truths. The use which is made in algebra of the letters of the alphabet, affords the best illustration of the nature of general reasoning, and of the principles on which it proceeds."

With regard, however, to the doctrine of abstraction, its chief errors have arisen from the supposed act of exclusion. We undoubtedly form, by the aid of memory and association, general ideas, or ideas of the general, most prevalent, and impressive features of whole classes or genera of external objects; and the proof I would adduce of this appears to me indisputable, namely, that we cannot supply the details which reduce the classes to orders, or the genera to species. Of these general ideas, general terms are the signs.

It is here, too, in connexion with understanding, that the second kind of evidence should be

mentioned; for its species belong entirely to the understanding of relations. I therefore deviate from the common method, or rather want of method, in separating the kinds of evidence, and noticing the latter here. Its principal species seem to be :—

1. Mathematical proof, in which one thing is merely shown to be identical with another already admitted.

2. Syllogistic proof, in which that which is predicated of an individual is shown to have been already conceded to a class.

This kind of evidence differs from intuitive, only in the greater complexity of the process; a perfect demonstration being constituted by a chain of reasoning, in which, however, each link is connected by intuitive evidence.

That the power of reasoning, says Stewart, "is implied in the powers of intuition and memory, appears also from an examination of the structure of syllogisms. It is impossible to conceive an understanding so formed, as to perceive the truth of the major and minor propositions, and not to perceive the truth of the conclusion. Indeed, as in this mode of stating an argument, the mind is led from universals to particulars, the truth of the conclusion must have been known before the major proposition is formed."

Reasoning is employed upon the results of understanding. The performance of one pro-

cess of understanding, its momentary discharge, and the instantaneous reception of another, in which, from their rapidity of succession and the permanence of their effects, these processes are compared, and their relations rendered obvious, appear to constitute the simplest process of reasoning.

Thus, still to adhere to as simple an exemplification as possible, the question immediately arising out of our last illustration might be, whether we should eat the cooling orange, or drink the heating champagne. In this case, the mind would alternately perform the brief process of understanding with regard to each, or would compare them with each other and with the wants of the vital system. It might further contemplate not only the momentary gratification which the use of either would afford, but its subsequent effects, the relation of the champagne to future habits, &c.

It was in reference to this higher process of reasoning, that I expressed opinions contained in an earlier part of the work.

Though facts, I then observed, are the first object in science, they are by no means the only object, or even the principal one : they are indeed valuable, only for the conclusions to which they lead and the purposes to which they may be applied.

"Long experience has moreover taught me

that we know little or nothing of facts till we know something of functions,—that we thereby, indeed, merely see objects, without knowing what we see!

"In the cultivation of science, in short—without facts, we are idle dreamers; without reasoning, we are trifling fools; and to the folly we add knavery, when we pretend that it is not yet time to reason, and throw on nature, or on science, the fault of our own incapacity. Facts and reasoning must go on together, or there is no real progress made. Their separate result is a chemical chaos, or a metaphysical phantasy."

It is here that we must briefly consider the method of reasoning and the kind of evidence which it admits; for in order to ensure as much certainty in its procedure as in the observations of the senses, reasoning is subjected to a method, which, if acurately employed, is infallible.

I. In inductive proof, we, by means of particular instances, establish a general law.

Our means of doing this are of two kinds—1st, observation, and 2dly, experiment.

In the phenomena of which we seek to obtain a knowledge by observation, it is obvious that either a single law of nature operates uniformly, or that different laws are always similarly combined. It is evident, therefore, that by carefully observing these phenomena, we may discover the law or laws on which they depend.

By artificial combinations of circumstances, also, or experiments, we sometimes discover conjunctions of phenomena which had not occurred to observation.

The method of observation is far more valuable than that of experiment, because the great operations of nature are infinitely more instructive than the little tricks of man, in which the performer too rarely knows what he himself has been doing. Nature, moreover, presents her phenomena in every possible stage, so that her operations become clear if we but observe and compare them; while the experiments of our chemistry produce new bodies which we mistake for old ones, and generally leave us as much in the dark, as do the lacerations of our living anatomy.

The method of observation furnishes also the kind of evidence, as already observed, which is most extensively applicable in science.* "But that method requires, that numerous facts, enlarged views, and powerful reasoning faculties, should be employed. If so conducted, indeed, its results are the most admirable that the mind can contemplate.

"The method of experiment is far more limited. It can be employed only upon matter that is under our hands. It can, moreover, be

* The expediency of giving *here* a brief view of mental physiology, renders it necessary to repeat a few paragraphs.

employed safely upon masses chiefly, and these inanimate.

"When experiment is employed upon the atoms or molecules, instead of the masses, of bodies, the circumstance of their being minute and unseen, and that of their combinations being little known, increases, of course, the chance of obscure result and unsatisfactory conclusion. If, for instance, as is often the case in chemistry, the intimate nature even of the liquid or fluid agent employed be imperfectly known, or it belong to those which must be deemed simple only because they are undecomposed, there is every probability of such experiment only encreasing that chaos of chemistry which such modes of procedure have already so extensively created.

"If experiment be employed not only on molecules, but these animated, or in the act of performing connected and complicated functions, it is worthless. If, for instance, as in physiology, and especially in the physiology of the nervous system, we have to deal not only with minute structure, which the very institution of experiment supposes to be but partially known,—but also with living functions of which we are utterly ignorant, and these functions likewise complicated with the influence of numerous connected parts,—of all which, moreover, the functions are equally unknown,—the performance of experi-

ment is the act of a person who has not the slightest notion of the use and application of experiment, and it becomes the mere play of a driveller or an idiot."

Now, by the comparison of facts, known from observation or experiment to be true, *we infer facts more general still.*

In this, the guiding principle is evidently analogy. This is sometimes the only mode of shunning a multiplicity of errors in every inductive process.

Analogy evidently requires, first that the individual case should be understood, and secondly that that case should strictly coincide with the nature of things, or with facts and experience already understood; for, without being clearly understood, no resemblance or analogy can possibly be perceived.

The great importance of analogy is therefore evident; and I accordingly observed that when the man of mere facts affects to deprecate analogy, he is ignorant that, while he may have but one series of facts, or rather facts unconnected and in no series, the analogist must not only have at least two series of facts, and stand above him even on that ground, but must also be his superior on a far higher ground, namely, that he knows not only facts, but the relations which subsist between them—the very next step to the discovery of the highest truth, and one

without which, in many instances, it cannot be reached.

For the kind of evidence of which physiology, and especially mental physiology, admits, I refer the reader to the Advertisement.

It is thus, then, that the philosopher establishes those simple laws on which the complicated phenomena of the universe depend.—And here ends the first part of this process.

II. Having, however, established these laws, the reasoner traces order, where the mere observer of facts sees only a chaos.

By the application of reasoning, he determines the effects resulting from the agency of any number of these, and deduces from them certain conclusions.

The first portion of this method is termed Analysis; the second, Synthesis.

The analytical method is especially necessary for the first investigation of truth. In it, we collect many facts, which, though at first a burthen to the memory, yet when compared with each other, enable us to ascend to original principles.

The synthetical method is especially necessary for the communication of truth. In it, we proceed from original principles to their complex combinations; and we find that, principles being established, each fact assumes its place in a general system, and by its relations to the rest, is easily retained in the memory.

Combined, these methods form the plan of induction, which, if accurately pursued, guides us as infallibly to truth as the observations of the sensitive organs: it constitutes the Novum Organon of Bacon—one of the noblest bequests that any man has yet bestowed on humanity.*

* I cannot lose this opportunity of making a few observations on the injustice with which the memory of Bacon has been treated, in the two matters of Essex and his supposed bribery as Chancellor.

In reply to the assertion "that though the charge against Essex were true, and his fate deserved, Bacon was not the man who should have urged them, and that, in doing so, he violated the principles of that gratitude, of which the obligation and the measure, if they have any foundation at all, are dependent on no reasoning, but on the general feelings and sentiments of all mankind," I may give various answers.

First, at the time when Essex laid him under obligation, Bacon had the firmness to assure him "that in becoming his homager, it was with the saving of his faith to the king and his other lords, and therefore he could become no more his than he was."

Secondly, the task as to Essex was insidiously imposed upon him by a most worthless and despotic queen and her ministry, in order to divert from themselves the national resentment.

Thirdly, notwithstanding Essex's errors, Bacon had long and zealously struggled in his behalf—and though he thought himself, by Essex's last rash act, acquitted of further interference in his favour—yet, so indelible was the remembrance of Essex's former kindness, that he took a deep interest in his safety, and performed the functions of his office with a mildness and a delicacy which elsewhere would in vain have

This operation is evidently performed in relation to that which succeeds it, and for the sake of which it is instituted.

been looked for. If any thing were wanting to determine this, it would be found in the conduct of Sir Edward Coke upon the same occasion.

Fourthly, the subsequent declaration, which brought upon him such obloquy, although drawn by him, was altered both by the queen and by her ministers.

The accusation of Bacon's receiving bribes alluded to by Pope and other witlings, appears to be absolutely untrue. Presents to the Chancellor were then common; the predecessors of Bacon had received them; they were matters of perfect publicity; they had become the perquisites of the office.

If that office ever were venal under Bacon's administration, it was evidently so only by, and for the profit of, the king and his favourite. But it is yet to be proved that Bacon ever decided wrongly even in the interest of these villains.

In relation to his own purity, it is especially worthy of notice, that the person who accused Bacon was one who, having made him a present, was not favoured by his decision; nor was Bacon, in any one case, found to have decided unjustly. When this fact is coupled with the preceding ones of custom, notoriety and cabal, the man must have singular want of feeling who can still criminate Bacon.

What would such a man say to other Chancellors who often express themselves thus:—"I decide here according to the practice of the court; but certainly had there been in such a case no instance of that practice on record, I should have decided otherwise." Whether is it the most unlucky thing for humanity, that a judge should have overlooked the continuance of certain old customs which were obviously wrong, but which influenced not the course of equity; or

Judgment, finally, is employed upon the results of reasoning, as reasoning was on those of understanding.

Thus, still adhering to the illustration previously adopted, the judgment in that case might be in favour of one of the objects of the previous reasoning, the orange or the champagne.

The principle upon which this preference took place, having been more or less perfectly reasoned, adopted with more or less entire confidence, and being now constituted a law less or more influencing our future actions, may be termed our hypothesis or theory upon the subject in question.

Upon such hypothesis or theory, all the acts of life which become habitual are founded; and it therefore becomes necessary that we should understand the nature of two such important operations.

The precise nature, use and value of hypothesis and theory, appear to be by no means generally understood. Theory, as formerly observed, is often deprecated; hypothesis, almost always. This is generally the result of ignorance.

that he should be compelled systematically and continually to prefer precedent to justice.

Bacon was the convenient sacrifice of a base favourite and baser king to a reforming parliament, which, like the present one, had not the honesty and the courage to attack crime in its strong holds.

Even the notion that while theory may be admitted, hypothesis is inadmissible in science, is entirely founded in error. Hypothesis and theory have both their value: both are essential to the progress of science.

Hypothesis is a conjecture or series of conjectures, concerning the causes and relations of events; and, as such it may be right or wrong.

Theory is the confirmation of such conjecture, or an absolute knowledge and rational assignment of these causes and relations; and as such it cannot err.

But I have stated, that as hypothesis is conjecture, so theory is its confirmation or actual knowledge. Now it is obvious, that where there is no conjecture, there can be no confirmation: where, therefore, there is no hypothesis, there can be no theory.

It is obvious, that we must suppose a reason before we can discover the number of the facts which support and confirm it—which transmute it from a hypothesis to a theory. We can never have a reason for bringing together any series of facts, but by means of a supposition, that their causes and relations are similar: without a hypothesis, we have no motive to do so.

Thus, even the suggestions of imagination are essential to the decisions of judgment. Hence

every true explanation must first be conjectural; or every theory must first be hypothesis.

Thus both hypothesis and theory are essential to the progress of science. But each has its sphere of applicability and use.

The value of theory—the principle founded on our knowledge of the causes and relations of events, cannot, for a moment, be questioned. It is by that means alone, that we discover the probable effects of any mode of action which it may be necessary to adopt under circumstances of the highest importance and the utmost emergency: it is by that means alone, that every act of our lives is not to us as a new experiment, and that, under very different circumstances, we precisely and confidently calculate results: it is, in short, by that means alone that we judge.

But while theory, the second, but highest object of science, is, as formerly observed, the great purpose for which facts are to be collected, it loses its character—it becomes mere hypothesis or supposition, if facts oppose it.

It is, however, as will presently appear, from this very value and the consequent misapplication of theory and hypothesis, that the greatest dangers to the progress of science have arisen, and that the utility of both has been doubted.

It must speedily have been felt, that the ca-

pability of discovering the causes and relations of events—the capability of theorizing conferred a decided pre-eminence upon its possessors. To such a pre-eminence all would aspire—all would attempt to theorise—many would inevitably err. Hypotheses must first have been formed; and in many suppositions upon one subject, one alone could throughout be correct. Error is manifold: truth is single. Hence, with the number of hypotheses the number of errors would accumulate; the order of their sequence would soon lead some to deem hypothesis the cause, and error the effect; and the opprobrium of the latter would soon be bestowed upon the former: men would, in fine, impute their own mistakes to the best methods of scientific enquiry. Hence hypothesis would soon be banished; and upon the same principles, even theory, as springing from it, would scarcely be tolerated in philosophy.

Such precisely has been their fate in the history of science. Their ultimate abandonment or neglect, has arisen from their very value, the wish to appear in possession of them, and their consequent misapplication.

We ought never to forget that, of all the false hypotheses which have held an empire over science, each in its turn, has obtained the admiration of those who lived during its epoch, and

each has also, in its turn, been thought to merit only the contempt or the invective of the following one. This ought certainly to warn us against that influence over the pursuits of science, which the authority of great names is so often permitted to assume. Better than this would it be to adopt as a maxim, that, in every question, the circumstances of which, admit and afford time for induction, the slightest reverence for authority proves a proportionate depression of intellect. The utmost caution is necessary in the adoption either of a hypothesis or a theory.

That hypothesis which would account for the greatest number of phenomena, must evidently be deemed the most probable; but that by which any phenomenon was unexplained, would not be entirely satisfactory; and that to which any was in absolute contradiction, must be rejected.

On the contrary, that which originates in facts, and affords the most probable solutions, is good; and that which, on any important subject, is contradicted by no fact, but corroborated by all the facts that are known to us, is inestimable.

When, however, a hypothesis even is adopted, the mind, if well constituted, must still be open to the impressions of the senses, and a new hypothesis, which may not less satisfactorily account for a greater number of these, must meet the more welcome reception.

In concluding this subject, I have but a few words to add respecting belief.

Belief is, in English dictionaries, defined to be "credit given to something which we know not of ourselves;" and "to believe," is said to be "to credit on the authority of another."

The foundation, or rather the nature, of this authority is pointed out by Locke, who says, "Probability is likeliness to be true, the very notation of the word signifying such a proposition for which there be arguments or proofs to make it pass for true. The entertainment the mind gives this sort of proposition, is called belief, assent, or opinion, which is the admitting or receiving any proposition for true, upon arguments or proofs that are found to persuade us to receive it as true, without certain knowledge that it is so."*

Belief might, therefore, more accurately be defined "the assent given to facts or arguments deemed probable, or presumed to be true."

The strength of belief, then, must depend on the strength of evidence, and on the probability thereby established,—on our recollections of physical or moral phenomena, and on the resemblance or analogy those now in question bear to them. When such analogies do not exist, the evidence is not believed.

* Essay on Human Understanding, chap. 15. sect. 1.

Now we have ascertained, that, to analogy, to all judgment of probability, and consequently to belief, understanding is necessary.

Hence, it is impossible for us to believe in that which we do not understand. We may persuade ourselves—we may so far destroy intellect as to persuade ourselves, that we do believe what we do not understand; but, without understanding, there can evidently be no real belief, and those who attempt to separate the one from the other, stand in much danger of never connecting them again.

It is, therefore, inaccurately that Mr. Hume observes, that belief in religious persons, subverts the understanding. Belief, as has just been observed, cannot exist without understanding, and consequently, where there is no understanding, there is no real belief, but an unfounded persuasion and a violation of intellect. Perhaps, by belief, Mr. Hume meant faith. But would that mend the matter?

Lord Bacon indeed says, that, "in matters of faith and religion, we raise our imagination above our reason, which is the cause why religion sought ever access to the mind by similitudes, types, parables, visions, dreams?"*—But I have sometimes doubts of his Lordship's orthodoxy.

* Advancement of Learning, Book II.

The mental process of discovering proofs of truth, or of bringing forward new truths, is called invention.

These three processes, then, namely understanding, reasoning, judging, differ from each other in their different complexity: the second forms, as it were a duplicature of the first; and the third forms a duplicature of the second.

There are other processes of the mind, either transient and undefined, or still more complex than the preceding, which need not here be noticed. They are all similarly explicable.

Thus with regard to sympathy, we are told that "we laugh or cry whenever we see it done by others, before we know, and consequently before we can reason respecting, their circumstances."

We do nevertheless reason in this case. We reason not, however, respecting its cause.—When any one cries, we know that there is grief or pain, and we are therefore grieved: when any one laughs, we know that there is joy or pleasure, and we are therefore happy, or in the language of mystery, we sympathise.

As a proof that this theory of sympathy is perfectly correct, it is only necessary to observe, that, with passions, which do not, like grief and joy, infallibly indicate their own cause, and so enable us to reason respecting them, such as

love, hatred, anger, &c., we never do sympathise.

In short, we seem instantly to sympathise with emotions, but not with passions, because we can reason safely respecting the former, but not respecting the latter.

CHAPTER V.

STRUCTURE AND FUNCTIONS OF THE PARTS CONNECTED WITH INVOLUNTARY MUSCULAR ACTION.

SECTION I.

STRUCTURE AND FUNCTION OF ASCENDING PARTS.

SIR C. BELL asserts that the middle column of each lateral division of the spinal cord is for respiration, and does not extend up into the brain, but "stops short in the medulla oblongata, being in function independent of reason, and capable of its office independently of the brain, or when separated from it."*

Now the column, of which these assertions are made for mere hypothetical purposes, is that commonly called the lateral column, or superiorly the olivary bundle, which, under the name of the fillet, Reil has shown to extend even into the fibrous cone of the cerebral hemispheres, and which, from numerous circumstances, appears to be the column on which all the involuntary muscular motions depend.

* Nerv. Syst. p. 24.

Reil has shown that either fillet or olivary bundle may be traced as far as the inferior margin of the transverse ring; that at this point it lies betwixt the pyramids and the upper margin of the olivary body; that *it is there continuous with that layer of the former which passes behind the superior transverse fibres of the transverse ring*, and with the bundles derived from the summit of the latter.

This passage of the lateral column, the olivary bundle, or fillet, *behind* the upper transverse fibres of the cerebellic ring, renders it sufficiently evident that these parts are freed from the influence of volition—that they are involuntary organs; and every other circumstance in their history corroborates this inference.

Reil has further shown, that inward, this bundle is bounded by the vertical bundles continued to the infundibulum, and outward, extends to the point at which the trifacial and facial nerves dip in; that just before it reaches this level, it divides; and that *one part* [the anterior] *is directed forward, immediately above the fibres of the pyramid, and passes below the dark substance.*

Tiedemann has shown that this portion of the olivary bundle, passes upward into the transverse ring, or is covered by this protuberance; that afterward it *remains in apposition with the superior external part of the pyramidal bundles;*

and that it *contributes with these to the formation of the peduncles of the brain.**

We know that the destination of the peduncles which they thus contribute to form, is to expand through the anterior striated bodies, into the fibrous cone.

The reader will here of course have noticed the remarkable circumstance, that *the anterior division of the lateral column or olivary bundles thus accompanies the anterior or ascending striated bodies, indicating thereby the course of its own advancing action.* He will afterwards see that *its posterior division accompanies the posterior or descending striated bodies, similarly indicating its returning action.*

It is further remarkable, that these two portions of the lateral column, though they thus pass above to different destinations, and though they easily divide throughout the length of the spinal cord, as in Mr. Mayo's experiment, are yet more perfectly in contact with each other than any of the other columns.

On this, probably, is in some measure dependent the facility with which the involuntary muscular action is returned, in consequence of excitement; and it is evidently through such

* Mr. Mayo also observes that the part of the fillet passing forward ascends in the cerebral peduncle above or behind its crust.

portions of these bundles as remain, that all those actions take place which are caused after the spinal cord is divided or the brain is removed.

Hence, if, in an animal just killed, the spinal cord be divided in the neck, on irritating the sole of the foot, that foot is retracted precisely as if the spinal cord were undivided, clearly proving that unconscious sensation with involuntary action is provided for by a corresponding set of nervous bundles.

The sensation and motion communicable from any section of the spinal cord alone, after decapitation, is of course unconscious sensation with involuntary motion; and it in no way abridges the proper functions of the brain, as MM. Magendie and Desmoulin imagine.

The white filaments of the spinal cord, as observed by Mr. Mayo, serve not only to connect the brain and oblong process with each segment of the cord, but to associate reciprocally the segments of which the cord itself consists.

Hence, if after cutting off the head of a snake, the skin of the tail be punctured, the headless neck turns instantly toward the irritated part, precisely as it would have done in menace or revenge, if in possession of their means.

Hence in acephalous infants, which survive for a short period, movements of an instinctive kind, are performed.

These cases show to what an extent animal actions are involuntary.

SECTION II.

STRUCTURE AND FUNCTION OF DESCENDING PARTS.

Here anatomy will be found in every particular to corroborate the views already taken. But in examining such details, it must be borne in mind, that here even the best anatomists, knowing nothing of function, have not distinguished between ascending and descending parts, but have generally treated every thing as ascending to the brain!

Reil, accordingly says, that the other part of the fillet, or olivary bundle, namely, that which does not ascend to the anterior striated bodies, having passed below the roots of the fifth and seventh nerves, strikes upward, emerges between the superior and lateral peduncles of the cerebel, and the peduncles of the brain,* and is then obliquely bent over the superior peduncle, at the outside of the inferior tubercle; that this portion, again, of the fillet divides; that one part, the external, attaches itself to the

* Reil more correctly inverts this order, when he elsewhere says "The fillet on the right side dips in between the anterior and lateral peduncles of the cerebel and the cerebral peduncle, to reach the floor of the fourth ventricle."

column of bundles which ascend behind the transverse ring, and passing below the geniculate body, joins apparently the fibrous cone; that the internal part inclines inward, and expands below the tubercles, principally the superior, so as to join its fellow of the opposite side in the median plane;* this inner subdivision of the fillet forms the roof of the passage between the third and fourth ventricles, and its upper central fibres are seen through their epithelium, at the interval between the superior tubercles; that the transverse white fibres of the posterior commissure (and he elsewhere says fibres which pass to the frenulum) are, like the preceding, continuations of this inner subdivision of the fillet; that, on raising the convex surfaces of the tubercles, and following this process of the fillet, a grey and vascular prominence is found, corresponding with each inferior tubercle, disposed transversely, having an obtuse termination outward, and narrowing inward; and that, at the inferior margin of each prominence, fibres of the fillet pass across, perhaps penetrate likewise below it.

Speaking of the same bundles, Tiedemann says, that the greater number of their fibres, which are longitudinal, collect in the common

* Reil elsewhere says that it is the third layer of the posterior striated body which is derived from the fillet.

mass of the tubercles, and bending upward and inward, uniting to those of the opposite side, form that portion which becomes the roof of the passage between the third and fourth venticles.

In describing this important part, I have thus far followed Reil and Tiedemann in their own detached or irregular way, because it was necessary to take up the description of the former where he had left it, after tracing the anterior or ascending portion of this column as passing to the anterior striated bodies and their radiation into the hemispheres.

That the posterior or descending portion of this column, which has just been spoken of, is as intimately connected with the posterior striated bodies and their concentration from the hemispheres, as the anterior portion was with the anterior striated bodies and their dispersion, will appear from other observations of both these anatomists; and it will thence be evident that, to both, the idea of advancing and returning action was alone wanting to better connected and more intelligible description, as well as to the exposition of function.

Speaking accordingly of the higher distribution of this returning portion of the olivary bundles, Reil here says, in the third clause above quoted, that "the external part attaches itself to the column of bundles which ascends behind the transverse ring, and passing below the

geniculate body, joins apparently the fibrous cone." In another place, after mentioning the portion which passes inward, to join its fellow of the opposite side, so as to form a curvilinear stratum of fibres immediately below the tubercles, he says "*the other plunges below the internal geniculate body into the posterior striated body of the same side, and extends apparently to join the fibrous cone.*" And again, in another place, he says that this portion of the olivary bundles "ascends underneath the process of the posterior tubercle; then, underneath the geniculate body, it extends into the posterior striated body, expands and blends with the production of the geniculate body, &c.: the three substances together pass on to join the fibrous cone." Reil's eleventh plate illustrates the concentration of this portion of the olivary bundles returning from the hemisphere.

Tiedemann also, similarly inverting functional order, says, that beneath the olivary fibres are situated those of the superior prolongations of the cerebel, which proceed forward, and partly cross with the oblique ascending fibres of the olivary bundles; and that these and *the anterior fibres of the same bundles pass into the posterior striated bodies.* And elsewhere he says that, at nine months, the olivary bundles proceed afterward, from below upward, between the pyramidal and the restiform bundles, and penetrating

the common mass of the tubercles, unite with those of the opposite side; and that some of the more anterior fibres pass into the posterior striated bodies.

As connected with this, I may add Reil's observation, that the fibres of the fillet are parallel to its course; and that the anterior peduncle of the cerebel is so slightly attached to it, that, on the removal of the epithelium, a probe may readily be passed between the two former substances.

The reader has now seen, in the words of the profoundest observers and highest authorities, that the lateral column or olivary bundles thus divide into two great portions, of which one, situated below and before, is connected with the anterior striated bodies, and the other, situated above and behind, is connected with the posterior striated bodies.

It has already been shewn, that the anterior striated bodies are ascending; and the posterior descending; and this junction of the two great portions of the lateral columns with these respectively, is another strong indication of their respective functions. The conclusion indeed is obvious, that the anterior portion of the olivary bundles which joins the anterior or ascending striated bodies, is also ascending, and that the posterior portion of the olivary bundles, which joins the posterior or descending striated bodies, is also descending.

The distinct separation of these less voluminous parts throws also light on that involvement of the more voluminous striated bodies, which has hitherto prevented a knowledge of their functions.

Like all posterior and descending parts, these are later in their formation than the anterior.

Tiedemann says, that it is not till the fourth month that we begin to distinguish the fibres which proceed from the spinal cord, between the pyramidal and the restiform bundles, and consequently coming from the middle bundles.

These posterior portions, then, of the olivary bundles descend under the transverse ring to form the posterior portions of the lateral columns of the spinal cord.

Thus, as already noticed, while the ascending and descending columns belonging to the fundamental parts, namely the pyramidal and restiform ones, are intimately connected with the cerebel—the pyramidal bundles, by interlacing with the transverse ring, and the restiform, by originating in the cerebel itself,—the olivary bundles, both in ascending and descending, intermix few or no fibres with it or its production.—This entire independence on the organ of volition is the best proof that they are involuntary parts.

Some connexion, nevertheless, they must have, since we find that involuntary actions may instantly give place to voluntary ones, as in res-

piration, expression of features, &c., and some connexion between these parts is probably the means of effecting this.

With the involuntary system, the posterior commissure seems to be so much connected as to be peculiarly the commissure of that system.

Reil says, that the transverse fibres of the posterior commissure are individually distinct behind, but apparently connected on the fore part into one bundle by epithelium; that, above it, is placed the pineal gland, connected by four peduncles to its anterior and posterior surfaces; that this commissure is prolonged in a white band along the upper and inner margin of the posterior striated bodies; that another process of this commissure passes transversely across the lateral processes of the anterior tubercles; and that a third seems to descend vertically in the posterior striated bodies to the anterior and outer margin of the same—at least he had often found a delicate nerve of the thickness of a horsehair, taking that course.

Tiedemann says, that on separating the hemispheres of the brain in reptiles and birds, we find them completely parted from one another superiorly, and merely united beneath by two commissures, the anterior and posterior, and also by the pineal gland; that, in the human fœtus, the posterior is apparent towards the end

of the third month; that transverse fibres are evidently seen in its tissue, and it becomes a true means of union between the two chambers; that in all mammiferous animals, its medullary pedicles arise from the superior surface of the posterior striated bodies, and even a little from the anterior tubercles; and that they are united together by a mass of reddish grey substance, which constitutes the gland itself, and which is hollow in the hind and sheep.

SECTION III.

STRUCTURE AND FUNCTION OF THE TUBERCLES, &c.

The relation of the posterior or descending portions of the olivary bundles and of their continuations in the posterior portions of the lateral columns of the spinal cord, to the tubercles and other ganglia, is the next thing to be shown, and to me it appears to be peculiarly interesting.

Of these ganglia, the first are the superior tubercles; then the inferior ones; lower down, the grey bands on the restiform bodies; and lower still, the olivary bodies.

These ganglia are more or less evidently connected with terminations of the optic, olfactory, auditory, and gustatory nerves respectively; and all of them are placed in contact with or actually upon the posterior or descending portions of the olivary bundles—a fact which I be-

lieve has not hitherto been observed, and which indicates, that as all these ganglia receive the ends of sensitive nerves, they are, points for a return of action.

The four tubercles appear to be very intimately connected with the olivary bundles and the involuntary actions.

Their connexion with the olivary bundles is such that these are found to be their productions, gradually expanding from them in the fœtus.

Their connexion with involuntary action is such, that, in the fœtus, they are relatively largest when that species of action predominates. They are also large compared with the brain, in proportion as the latter is simpler ; and, in such cases, there is every indication that involuntary prevails over voluntary action.

In fishes, they arise laterally from cords continued from the spinal, and expanding into a sort of membrane, are reflected inwards. The cavities thus formed contain, except in the ray and shark, small eminences or folds varying much in number, form and size, which rest on the anterior prolongations of the spinal cord.

In the brains of many reptiles, are seen white fibres rising from the part described and spreading into the walls of these eminences.

In amphibia and birds, as well as fishes, the tubercles contain a cavity, which becomes smaller as we ascend to mammalia.

In man and mammalia, the tubercles are, in the first instance, hollow.

In birds, the anterior masses do not extend so far back as to cover the tubercles.

In mice, rats, shrews and bats, they project upward, and lie behind rather than below the anterior mass.

In mammalia, they recede, and have appended to them a second pair.

The anterior pair are largest in the ruminantia, solipeda, rodentia, moles, shrews and bats. The posterior pair are largest in the carnivora. Those which have been deemed a third pair, become, in the lemur and the dog, as large as the other pairs.

The two pairs are nearly of the same size in man and the quadrumana. In man, however, the anterior are sometimes more developed than the posterior, while sometimes the reverse is the case.

In the dolphin, the posterior are at least triple the size of the anterior.

Reil states, that the tubercles have four round caps of grey matter, which are placed on the radiation of the fillet [or posterior part of the olivary bundle]; that before and behind the tubercles, and below the anterior pair, that radiation may be traced; and that the substance of the posterior tubercles extends the deepest; so

that these remain, after the exposure of the radiation of the fillet.

Tiedemann similarly says that, when we scrape the tubercle externally with the flat handle of a knife, we expose the ascending fibres of the olivary bundles.

The grey kernels in the posterior tubercles, exposed on the removal of the epithelium and a thin white layer, are about the size of a barley-corn, and lie with their points towards each other. These seem to be mere nodules of grey matter united by medullary fibres; and a few fibres of the posterior portion of the fillet pass below them to the frænulum.

In mammiferous animals, certain branches of the optic nerves distinctly end in the anterior tubercles. Accordingly, these tubercles are in every class developed in the direct ratio of the size of the optic nerves and eyes.

Vicq d'Azyr remarks that these tubercles have a ventricle in birds in which the sense of sight is the most acute, as the olfactory nerves in the mammalia, in which the sense of smell is superior to the others.

The connexion of the nerves of vision with these tubercles, is worthy of remark.—Having elsewhere shown that emotions of pleasure or pain are especially dependent on vision, and it being evident that emotions are involuntary, this

connexion of the optic nerves with the involuntary organs, is not less remarkable than that of the auditory nerves with the cerebel—that of the nerves specially exciting desire or aversion, which are evidently voluntary, with the organ of volition itself.

From many circumstances, the posterior tubercles appear to have the same relation to the sense of smell.

It is evidently owing to one root, in the case of some nerves, being sent to the tubercles, that some sensations produce effects when the brain and cerebel have been removed.

Reil states that the tubercles have processes which plunge anteriorly and laterally into the posterior striated bodies; and more particularly that it is above the internal geniculate bodies, that the processes of the upper tubercles, and below them, that the processes of the under ones enter these striated bodies.

Of the fibres from the superior tubercles, Rolando observes that the inferior fibres go to the posterior striated bodies, and the superior ones form the roots of the optic tracks.—And this seems to indicate another termination of the optic nerve in the middle lobe.

Tracing these upward, Rolando further observes, that posterior to the fibres from the posterior striated bodies, a large bundle on each side ascends from the superior tubercles.

From the processes of the posterior tubercles, Reil observes that fibres seem to proceed, in a curvilinear direction, over the geniculate bodies to the posterior margins of the posterior striated bodies.—And this may indicate a termination of the olfactory nerve in the middle lobe; for, speaking of the bed of grey substance analogous to the posterior tubercles in either posterior striated body, he says that it occupies the internal and posterior part of the latter; and that from this are derived bundles, which partly join the radiation of the fibrous cone, occupying its fore part; but some internal to the others, bend round the margin of the cerebral peduncle, forming the medulla incognita—a substance with which, be it observed, another termination of the olfactory nerve appears to be connected.

In man and the quadrumana, these parts are relatively least; they are larger in the carnivora; still larger in the ruminantia and solipeda; and largest in the rodentia and bat genus. And from the character of the respective animals, it seems probable, that the involuntary actions encrease with them.

The spinal cord, the middle lobe of the brain, the tubercles, and the middle lobe of the cerebel are developed in a direct ratio to one another.

As to the general function of these parts, it has been already observed, that in the fœtus,

they are relatively largest when that species of action predominates.

In Cuvier's Report to the Institute of France on the "Anatomie Comparée du Cerveau" of Serres, it is observed that "the tubercles are the first portions of the brain which are formed; their formation always preceding that of the cerebel, in the embrios of birds, reptiles, mammalia and man"—a fact which corresponds with the predominance of involuntary motions at that period.

It has also been observed that the tubercles are large compared with the brain, in proportion as the latter is simpler; and, in such cases, there is every indication that involuntary prevails over voluntary action.

Serres observes that these tubercles are larger as we descend among animals [to the brain of which that of the human embrio approximates]—being least in man,* larger in mammalia, still larger in birds, larger still in reptiles, and largest in fishes.—Tiedemann had stated these facts, most likely before the French anatomists.

Such indeed is the importance of the tubercles among the three inferior classes, that while,

* Longitudo et latitudo corporum quadrigeminorum in aliis a nobis examinatis mammalibus absolute, in aliis relative ad longitudinem latitudinemque cerebri ipsorum major est, quam in homine.—*Wenzel*—*De Penitiori Structura Cerebri, p.* 259.

in them, the cerebral lobes are solid, these tubercles have ventricles. But this last is in relation to the senses of which the nerves there terminate—those of vision certainly, and probably those of smell—senses intimately connected with involuntary action.

Hence evidently it is, that the oblong process is the agent of muscular irritability; and that the tubercles in particular participate in this irritant power, and produce, as it does, convulsions when stimulated. Hence it is that sensibility and contractility seem two inseparable faculties, if not identically the same, as in animals not possessing a distinct nervous system, and even in plants.

As the four preceding tubercles are found above the cerebel, and correspond to the more involuntary nerves of vision and smell, so are other four found below the cerebel, and correspond to the more voluntary nerves of hearing and taste.

Of these the first pair are the grey bands in which one of the terminations of the auditory nerves takes place. These are formed precisely where the posterior or descending olivary bundles are turning, from behind and above, forward and downward.

The olivary or lateral columns are soon after divided by the olivary bodies which are placed quite anteriorly.

These bodies are formed of a white crust

covering a thin yellowish red substance, which presents a number of folds, while the centre is composed of brown substance.

The olivary bodies are wanting in fishes, reptiles and birds; and they cannot be said to exist even in quadrupeds; but the latter have in the same situation a quantity of brown substance, without any arborescent ramification.

Rolando describes a singular arrangement of filaments around the olivary bodies, a crossing of them taking place immediately below these bodies and a recrossing above them, so that they grasp these bodies between them.

Tiedemann observes that the olivary bodies are formed only towards the end of the sixth month, or on the commencement of the seventh, a period when the unfibrous substance which constitutes them is secreted on the white substance of the olivary bundles.

As already observed, the curious fact has not hitherto been pointed out, that all of these ganglia are formed on these posterior, or, as I have termed them, descending portions of the olivary bundles, and that they follow the peculiar winding course of these bodies, being—superiorly (the tubercles) behind,—midway (the grey bands) on the side,—and inferiorly (the olivary bodies) before.

In these cases, then, we have certain terminations of nerves of sensation joining bundles on

which involuntary action depends, which clearly indicates that, by that means, such action may immediately follow sensation, independently of any communication of these motions to the hemispheres.

This fact indicates, for the first time, the reason why the olfactory and other nerves of sense have several terminations in the brain, as has either been already seen or will be seen in the sequel; and it throws great light on the terminations of nerves in general.

There can be no doubt that other terminations of the same nerves pass to the hemispheres and lead to voluntary action. Indeed, either structure or function proves this in every case.

Ignorance of the uniformity and necessity for these several terminations in the brain, belonging to nerves of pure sensation, has greatly misled the experimenters on living animals, who consequently could not conceive why impressions on the senses should end in action when the brain and cerebel were removed.

The fact, however, that impressions on the senses do end in action when the brain and cerebel are removed, proves that their influence is communicated by the nervous terminations and ganglia now spoken of, and also that the actions then induced are involuntary ones.

It seems probable, however, that these are

not the whole of the ganglia that are formed upon the posterior or descending portions of the olivary bundles. These portions of the olivary bundles become the posterior and descending portions of the lateral columns of the spinal cord; and it is upon the posterior roots of nerves, arising partly from these, that the intervertebral ganglia are formed.

Now, when we bear in mind, that the ganglia on the sympathetic nerve are evidently connected with a return of action and with the involuntary motion of the parts it supplies, and that the four pairs of ganglia described above are similarly connected with a return of action and with involuntary motion, it must appear highly probable that the ganglia on the posterior roots of spinal nerves have also to do with a return of action and with involuntary motion—in short, that there is in these ganglia, a connexion between those fibrils of the posterior roots which the same olivary or lateral, descending and involuntary, bundles supply, and some other fibrils ascending to meet them and to excite returning and involuntary motion by their means.—We shall afterwards see that some at least of the fibrils which join them are twigs of the sympathetic.

It would hence appear that all ganglia are organs of return as to nervous action. Instead, therefore, of a ganglion being a sign of a nerve

of sensation (and, to hear the existing language of physiology, one would imagine its forming such a sign was a very sufficient purpose of its existence, just as an illiterate person ties a knot on a string for the purpose of helping his memory)—instead of this, however, ganglionic nerves always indicate a return of action and therefore motion as well as sensation.

We shall accordingly find, that wherever motion—more particularly involuntary motion, predominates, ganglia are found, and where it is encreased, these ganglia are enlarged—sometimes to great extent.

Further confirmation of this view, that these ganglionic nerves (in man the posterior spinal roots, &c.) belong to locomotion, may be found in fishes, in which the genus trigla (the flying fish) in consequence of its having the pectoral fins greatly developed for the purpose of locomotion by flight, has to each pair of nerves supplying them, a corresponding pair of large ganglia on the upper side of the spinal cord.

The flying fish, says Serres, is remarkable on account of the detached rays of its pectoral fins, and similarly by a series of enlargements on the posterior part of the spinal cord, proportioned, both in number and size, to the number of the rays to which they correspond.

Tiedemann observes, that the remarkable and regularly disposed enlargements observed imme-

diately behind the cerebel in the flying fish, are the origins of the nerves destined to the digitiform prolongations peculiar to these fishes, observed in front of the ventral fins, and provided with numerous muscles, serving at the same time as organs of touch and progression.

The three last words here employed by Tiedemann, strikingly accord with that return of nervous action I have ascribed to ganglia.

The same view is illustrated by the nodules on the upper part of the spinal cord of the gurnet, from which the nerves supplying the feelers are given off.

The silurus, an electrical fish, has a considerable enlargement corresponding to the nerve distributed to the electrical apparatus; and there can be no question as to the direction in which motion thence takes place.

We find also in the torpedo, two large ganglia situated behind the cerebel, the size of which they much surpass, whence issue the nerves analogous to the eighth pair, which furnish numerous branches to its electrical organs.

Moreover, in every class, the intervertebral ganglia are proportioned to the size of the nerves which traverse them; being larger near the limbs than elsewhere.

Thus, in every case, these ganglia are connected with motion; and there is not the shadow of argument in behalf of the mere hypothetical

assertion that the ganglia on the posterior spinal roots are *signs* of their being nerves of sensation. On the contrary, these ganglia appear to afford the most decided proofs that these roots are in some degree those of involuntary motion.

There is an interesting view which should be taken in this place. Although peculiar ganglia are found in some fishes, yet the common ganglia of the whole system gradually but remarkably diminish and even seem finally to disappear, as we descend among animals. It has not been observed that this diminution and disappearance accompanies the diminution of the higher mental systems; but this clearly indicates that, in lower animals, ganglia are no longer necessary as intermediate between a lower and a higher system, as in this section has been shown to be the general condition and purpose of their existence. This view, therefore, while interesting in itself, affords another corroboration of the truth, that the ganglia are always organs of a return of action.

It appears to me that the functions of this involuntary organ are much more extensive than is commonly imagined; and that whenever we perform external motions, while thought and will are otherwise engaged (a matter of frequent occurrence), the voluntary have insensibly changed into involuntary actions, by means of this organ.

Thus, if deeply engaged in conversation while

walking, we often perform the same habitual and involuntary progression, until we find that we have taken the wrong road; and, at all times, we are compelled to suspend the internal actions of the thought and will, and to resume voluntary progression, if a crossing or obstacle interfere.

It may even be argued that walking at no time consists of actions all of which are voluntary, for many of the motions we employ in it are unconsciously performed, and have been perhaps so often associated that it would require great exertion to separate them voluntarily: they have become involuntary.

Even in writing the preceding paragraphs, an illustration of this occurred to me. My mind was, for a moment, directed inward; if I saw the paper or the writing, I was unconscious of doing so; and my will was entirely withdrawn from the act of my hand, to guide an internal act, a momentary distraction of the mind. The duration of this distraction was such as to make me, at the instant of again bringing back to this writing my consciousness and will, exclaim to myself that I must, during this brief period, have been writing inaccurately. On again seeing the paper, however, I found I had correctly written the long word I had just begun, when consciousness and will were withdrawn from it. Those who often direct their minds inwardly, will discover too many illustrations of the same kind.

CHAPTER VI.

STRUCTURE AND FUNCTIONS OF THE PARTS CONNECTED WITH THE VITAL SYSTEM.

SECTION I.

STRUCTURE AND FUNCTION OF THE SYMPATHETIC SYSTEM.

Among the zoophytes, the lowest class of animals, the holothuriæ and sipunculi display nerves; but they are those only of the vital system, as they form a circle around the gullet—the most elementary, simple and essential form in which nerves appear, and to which exists a corresponding arrangement in the higher animals, where it is always appropriated to the vital system.

In the star-fish, a cord around the orifice of the alimentary cavity is the central part of the system, from which, opposite each ray, nerves are given off.

The mollusca, the class immediately above the zoophytes, have still the circle around the

gullet, but larger ganglia gradually approximate on the upper side of the animal.

In all the four superior classes, there is a nervous cord on each side of the front of the vertebral column, which connects together the branches from the spinal cord destined to the vital system, and seems to form a medium between it and the mental and locomotive system. It is thus connected with the proper intervertebral nerves and with those analogous to them in the head.

The sympathetic nerves, then, evidently form a system, distinct from the two already described, and give sensation and motion to the organs of life.

The nerves of the two preceding systems proceed more directly from the brain or from the spinal cord, whereas the surfaces and the muscular coats of the vital organs are, for the most part, supplied immediately from ganglia.

A ganglion is a nodule of circular or oval shape, and of reddish grey colour, never found but when there is a meeting of fibrils or nerves of different kind.

One of the most important of these is the semilunar ganglion, which is situated behind the viscera of the epigastric region and from which arise the nerves that supply most of the abdominal organs.

Filaments proceeding from several nerves,

very often unite in one of these ganglia, from which other filaments arise, and are transmitted to different parts.

The nerves below a ganglion are generally larger than those above it.

The filaments of the sympathetic nerves are finer, softer and redder than those of the cerebral nerves.

The numerous plexuses of the thorax and abdomen permit the diffusion of influence from these nerves.

The sympathetic nerves supply the vital system, wherever its parts may be situated.

These nerves form a net-work around all the great arteries, and may be followed on the larger branches of the head and extremities. Even the cerebral arteries are accompanied by filaments from these nerves.

From analogy, we must conclude, that the capillary arteries are similarly supplied — even those of the brain itself.

The same system supplies all the secreting glands and surfaces. It also supplies the vena portæ throughout.

Both in the lower animals, and in the embrios of the higher, the ganglia of this system, according to Dr. Copland, appear before the spinal cord or the brain.

The chief physiological difficulty with regard to these nerves has been why, being nerves of

sensation, their sensations do not reach the sensorium commune, or why they are not perceived. As some peculiar construction evidently is necessary to prevent this, it is natural to look, in the nerves themselves, for that peculiarity; and it is to be found in their ganglia.

The ganglia appear to impede sensation, and prevent the brain being disturbed by all the impressions on the viscera, which would have been incompatible with thought. They also prevent their uniform and perpetually recurring actions from being communicated to the brain and unnecessarily disturbing the functions of that organ.

In the ganglia, moreover, the nerves of sensation terminate, but they are there connected with the nerves of motion, so that the nervous influence, returning to the muscular fibres, produces action.

Involuntary vital parts, indeed, are simple as to motion. Being tubular, mere contraction suffices. Hence the return through ganglia is enough.

The view here taken is most nearly approached by that of Winslow, who regarded the ganglia as smaller brains, and who has been followed by the French anatomists. Johnstone supposed that their use is to render the organs which derive their nerves from them independent of the will, which, so far as it went, was

correct; and the supposition that Haller refuted this, arises only from Johnstone and his followers seeing but a part of the truth as to these organs.

From the internal structure of the ganglia, as described by Scarpa, they appear to me to be mere mechanical means facilitating a returning instead of a progressive motion.

It does not follow, however, that all the fibrils of nerves on which ganglia are formed, belong to impeded sensation and returning motion; for, in the ganglia, many nervous fibrils are seen running over the whole length of the ganglion, and having no intimate connexion with it.

These nerves are connected with the brain by so few of those filaments which lead to perception, that in general their accidents are not felt, and they can in return be little influenced by the brain.

A ganglion of the sympathetic system may be removed without pain in any great degree being caused to the animal.

It is not here meant that these nerves are insusceptible of pain from certain causes; for when this system is called into that morbid action against which it seems in general so carefully guarded, no pain is so extreme as that which it communicates.

It is a gross error, however, to say that the branches and ganglia of the sympathetic nerve

are insensible, because in the living body, they may be injured without producing perception and consciousness. Those who write thus do not even know the meaning of the terms they employ, and evidently confound sensation and perception together.

While galvanism powerfully affects other nerves, it scarcely at all influences the ganglionic system, as shown by Dr. Copland, who has clearly demonstrated the independence of that system.

The ganglia, then, appear to be the sole cause why neither cerebral nor spinal impulse, nor galvanism, affects the heart and other important vital organs, and also why these organs do not affect the brain and spinal cord.

It is remarkable that in fishes, the sympathetic nerves are nearly, if not completely, without ganglia; that, in many reptiles, the ganglia seem still to be indistinct; that in birds, they become much less so, and at each vertebra is found a ganglion; while, in mammalia, the number of the ganglia no longer corresponds to the number of vertebræ.

It appears to me that, in the lower of these classes, the cerebro-spinal part of the nervous system is more of an involuntary character, while that part of it which is connected with life, may probably be less so, and consequently that the latter requires less of distinction in

this respect—fewer and smaller means of union and of a return of action; while the reverse is the case in the higher classes.

In the highest classes, the heart, the stomach, the intestinal canal, &c. by being supplied by ganglionic nerves, act independently of the will; while the diaphragm, rectum, and bladder are subject to the will, because they receive nerves from the brain as well as from the sympathetic system,—the rectum and bladder from sacral branches, through the hypogastric plexus, and the diaphragm, in consequence of nerves sent to it from the fifth and sixth cervical pairs.

If, as has been observed, these latter organs had received their nerves of motion from the sympathetic system, their action would have been independent of the will.

Some actions of the intestines or blood-vessels may be continued for a time after the removal of the brain, because their action is less immediately dependent on the brain than that of other parts, and because the stimulus which excites them to act—the food, or the blood, remains within them after death, and for a time produces its usual effects.

Wherever the spinal nerves communicate with the sympathetic, there is a ganglion at the place of union; and, as already stated, another is formed on the posterior root of the spinal nerve in its vicinity.

We may now endeavour to answer the question of Soemmerring on this subject—"Qua causa est," says he, "cur, in radice posteriore tantum nervorum spinalium, ganglia inveniuntur, minime autem in priore?" And again, "Cur radix prior nervorum spinæ medullæ, adeo vicina, ganglio non immiscitur?"

The junction of the sympathetic with the spinal nerves is peculiarly interesting on several accounts.

In the first place, that junction occasionally is directly with the posterior root and its ganglion; and whenever it is made by a single bundle of fibres with the anterior branch, it is of course below the crossing, whence it ascends the posterior root, and that indeed is often superficially visible. The junction is, therefore, with both roots.

In the second place, these connexions with both roots, are always by fibres which evidently both ascend and descend upon them, and consequently which are both given to and received from them. This is also evident in the junctions of the sympathetic with cerebral nerves.

It is probable, from all that has already been said, that the fibres which join the anterior root are, like that root, those of sensation—those below or externally conveying it from the coats of vessels, &c. to the sympathetic system, and those above or internally conveying it, in how-

ever slight a degree or however modified, from that system to the brain.

It is also probable that the fibres which join the posterior root are, like that root, those of motion—those above or internally, conveying it from the brain to the sympathetic system, and those below or externally, conveying it from that system to the coats of vessels, &c.

But it is a fact, that the system of nerves subservient to life is everywhere closely connected with the system subservient to involuntary muscular action which was described in the sections of the last chapter. This will be rendered more evident in the present chapter, as to the bundles connected with life in the oblong process, which lie immediately under those connected with involuntary muscular motion in the tubercles. Meanwhile examples of involuntary muscular association with the sympathetic system are seen in the exclusive supply which the latter gives to the heart, stomach, intestinal canal, glands, &c.

But the connexion of this system with the involuntary muscular one does not terminate there. Not only is every analogy in favour of these systems being connected throughout, but we everywhere see external demonstrations of this not only in the regular actions of parts already mentioned, but in innumerable involuntary affections of the muscles generally caused

by various states of the vital organs and conveyed to the muscular ones, as they must be, by the sympathetic system alone.

Now it has been already shewn that the olivary bundles, on which involuntary muscular motion depends, and which on that account are connected with so many pairs of ganglia in the brain, are continued in the posterior parts of each lateral column of the spinal cord, and consequently contribute to the origins of spinal nerves called the posterior roots, on which again the ganglia now in question are formed.

Were we, therefore, only to bear this analogy in mind, and the law which it seems to indicate, namely that all ganglia are thus connected with involuntary action, we should be disposed to conclude that such was the purpose of the ganglia here.

When we further reflect that all action returned from ganglia must be involuntary, because it is thereby prevented from reaching the organ of volition, we shall be confirmed in this opinion.

It remains for us only to discover the new nerves which at such points, as in previous instances, join these roots; and we find under our eyes the fibres from the sympathetic system forming so obvious a junction with these roots, that their obviousness alone, or I should perhaps say that familiarity with them which has

preceded all supposition of difficulty and consequent enquiry, has caused us to overlook them.

The ganglia, therefore, on the posterior roots of the spinal nerves appear to be those in which a junction takes place between the sympathetic and the involuntary muscular system.

Finally, then, as to ganglia, wherever they are, there is a return of motion. Such is the case in the ganglia of the abdomen, in those of the fifth pair which approach the former, in those formed on the fillets or descending portions of the olivary fasciculi, and in those doubtless on the posterior roots of the spinal nerves.

SECTION II.

STRUCTURE AND FUNCTION OF APPARENTLY ASCENDING PARTS.

It has been already indicated by various circumstances, that the nerves of the vital system communicate with the brain. As indeed, both in health and disease, the influence of the sympathetic system is transmitted to the brain, and that of the brain to the sympathetic system, it is evident that bundles appropriated to these two purposes must exist in the spinal cord.

These are doubtless those bundles not hitherto noticed here, but described by Reil, and

having a texture, especially the anterior, greatly resembling the ganglionic system.

He says another layer, the vertical bundles, composed not of nervous matter alone, but of cellular membrane likewise, and vessels in unusual proportion, as may be conjectured from its toughness [he elsewhere says a thick and broad stratum of longitudinal fibres, which in its ascent from the oblong process, is joined on either side by the fillet] extends from behind the pyramids, behind the upper transverse fibres of the transverse ring [he elsewhere adds between the middle peduncles of the cerebel, or at the floor of the fourth ventricle, covered only by grey matter], and below the ansa of the anterior peduncle of the cerebel, to the grey substance which is found between the peduncles of the brain, extending beyond the pisiform eminences, thus building the floor of the third ventricle, and becoming continuous with the infundibulum. The fibres of this layer seem in some degree to decussate each other.

Here, then, is a thick and broad layer extending behind the pyramids, behind the upper fibres of the transverse ring, between the middle peduncles of the cerebel or at the floor of the fourth ventricle, below the ansa of the anterior peduncles of the cerebel, to the grey substance between the peduncles of the brain, extending beyond the pisiform eminences, building the

floor of the third ventricle, and becoming continuous with the infundibulum— in short, occupying the whole of that portion of the brain with which life seems to be especially connected.*

This layer appears to be the continuance of the similarly single layer of the spinal cord which is immediately behind the transverse commissure at the bottom of its anterior fissure. Neither, indeed, of these layers may be single, but double and in contact. If the former, however, we have double perceptive, double involuntary muscular, and single vital columns.

It is particularly to be observed, Reil adds, that this thick and broad layer of longitudinal fibres appears to have no connexion with the pyramids, but further *forward it runs on together with the radiation of the peduncles.*†—This

* The fibres which Mr. Mayo describes as lying behind the anterior pyramid and the central part of the cerebellic ring, appear to be Reil's thick and broad layer of longitudinal fibres behind the transverse fibres of the ring and between the middle peduncles of the cerebel, or at the floor of the fourth ventricle, covered only by grey matter, and which in its ascent from the oblong process is joined on either side by the fillet.

† Ueber der obersten Schicht von Querfasern der Brücke und swischen den seitlichen Schenkeln des kleinen Gehirns liegt noch in der Tiefe des Grundes der vierten Hirnhöhle ein dickes und breites Stratum von Längen-Fasern, welches die Schleifen von beiden Seiten aufnimmt, mit den Pyramiden keine Verbindung zu haben scheint, aber *vorwärts mit*

connexion with the peduncles shows, as before, that this layer belongs to the ascending masses; and to me, it appears that it passes to the lower part of the middle lobes, which are obviously connected with the vital system.

Thus the nerves of the vital system are not confined to the trunk, but ascend to the head, and as smell and taste are there the senses of that system, they have a portion of the hemispheres devoted to their perceptions, and connected with the rest of the nervous system of life.

SECTION III.

STRUCTURE AND FUNCTION OF THE LOWER MIDDLE OR INFERIOR LOBES.

The circumstances which, in all animals, characterize the lower middle or inferior lobes are 1st. that the olfactory nerves pass toward them, and 2dly. that they and the olfactory nerves are united by the anterior commissure. The neglect of these characteristics has led to great errors even among the best anatomists.

Reil states, that, in man, the anterior commissure extends transversely across the brain,

der Radiation der Hirnschenkel zusammenfliesst.—Archiv. für die Physiologie, Neunter Band, p. 149.

from the middle lobe of one side to that of the opposite; and again, that it passes between the first bundles of the fibrous cone, and then spreads itself out in the under surface of the middle lobe.

Tiedemann says, that, in such of the mammiferous animals (in particular among the carnivora, as the dog, and among the ruminantia and rodentia) as possess the olfactory nerves well developed, the anterior commissure unites also the two enlargements of these nerves; a remark which had previously been made by Cuvier.

Reil further observes that, in sheep, the anterior commissure, as if composed of two cylinders in apposition, divides at either end into an anterior and posterior branch; that the anterior branch bends itself forward at the foremost bundle of the fibrous cone towards the mamillary process, or mass formed by the olfactory nerve, and its outer wall; and that it is lost, where the latter meets by a narrow opening the anterior horn, in radiated fibres, which surround this opening.

With these facts and authorities as bases, let us consider the parts which appear to correspond in inferior animals.

In fishes, the first cerebral mass consists of a variable number of ganglia in different species, but of these the most universal and most essen-

tial is the pair immediately in front of the tubercles over which pass the optic nerves, and in which terminate the olfactory nerves. They are composed of grey substance, united by a small white commissure which is evidently that called, in man and mammalia, the commissure of the lower middle or inferior lobes, or the anterior commissure.

Tiedemann observes, that some fibres of the peduncles of the brain pass into their interior, and are lost in the olfactory nerves, to which they give origin.—I suspect that these peduncles are little more than the bundles connected with the vital system which we are now describing.

Be this as it may, from the close relation of these bodies to the olfactory nerves and anterior commissure, and from their correspondence to the lower middle or inferior lobes of higher animals, it is evident that Tiedemann errs in thinking they correspond to the anterior striated bodies; and Desmoulins, much more, in thinking they correspond to the posterior striated bodies.

Tiedemann, in his Icones Cerebri, speaking of the lower part of the middle lobes in the lion, calls them "Protuberantiae quaedam s. colles, quas Malacarne (Memorie della reale Academia di scienze di Mantoua. T. 1. p. 71) protuberantias natiformes, celeberr. Treviranus autem pyri-

formes vocat. Hae protuberantiae in basi cerebri omnium ferarum aliorumque mammalium, quae processibus mammillaribus gaudent, observantur, atque *inter earum magnitudinem et massam processuum mammillarium ratio directa intercedit.* Pedes hippocampi s. cornua ammonis in protuberantias pyriformes dimittuntur."

And again, reversing functional order, in speaking of the nasua, he says "*Eminentiae pyriformes, quae a parte posteriore cerebri descendunt, inque processus mammillares nervorum olfactoriorum abeunt.*"

Similarly reversing functional order, in speaking of the cavia, he says "Eminentiae pyriformes lobi medii, in nervos olfactorios progredientes." Again "Massa quaedam cerebri, sulco longitudinali satis profundo a superiore encephali parte separata, quam celeberrimus Treviranus lobum inferiorem cerebri nominavit. Haec massa a facie posteriore cerebri descendit, et ad nervum olfactorium s. processum mammillarem tendit." And again "Lobi inferiores cerebri, in quos pedes hippocampi sese dimittunt. Ceterum notatu dignum est, quod hi lobi cum nervis olfactoriis commercium habent, vel potius in processus mammillares abeunt."

Whoever examines this inferior lobe in the plates of Tiedemann, and especially in those which represent the brains of the two last mentioned animals, will be surprised at its distinct-

ness from the rest of the brain; but he will not be less surprised that, forgetting what he saw here, Tiedemann himself should have reckoned the cerebral masses which similarly receive the olfactory nerves in fishes, &c. as corresponding to the anterior striated bodies! This, as in the case of Reil, is the result of not knowing what one sees, of never dreaming of function, and of reversing functional order.

As to the cavities in these bodies, Tiedemann himself observes, that the first animals in which they are observed are the ray and shark, where we find them in the anterior masses of the brain, whence they are prolonged into the interior of the olfactory nerves. Arsaky also observes, that these masses are hollow, and have their cavity prolonged into these nerves.

The cavity, therefore, in this cerebral mass, from its close relation to the olfactory nerves, does not properly correspond to the lateral ventricles of man, or at most but to that portion of them which is found in the inferior lobes.

It is consistent with these views that the inferior horn of the lateral ventricle is, as observed by the Wenzels, proportionally greater in mammalia than in man.

As, however, we ascend among animals, we find the anterior masses become gradually developed. They encrease vastly in size, and at last overhang and rest upon the olfactory pro-

longations, which still run back to the middle lobes.

This last fact decidedly proves, that the original masses to which these nerves were attached were only the inferior lobes, and that the anterior lobes are only gradually superadded and placed before them.

As these inferior lobes become developed, their cavities, though still extending into the olfactory prolongations, gradually present within them nodules analogous to the striated bodies.

Thus also the ventricles of the inferior lobes become the lateral ventricles.

I cannot help saying, that, amidst such accumulation of facts as exists on this subject, it seems really surprising, that these anatomists should have failed, I will not say to reason, but to draw more correctly the analogies on which, by the aid of comparative anatomy, all reasoning as to function must be founded.

The development of these lobes, then, in the lower animals, in which the higher mental structure is always wanting, and in the human fœtus, when life and its structures predominate over mind, sufficiently show the purposes of these lobes, as belonging to the vital system. They are obviously the perceptive organ at least of the olfactory nerves—those guides which direct us to the proper supply of the vital system.

A few words should here be added as to the anterior commissure, which is evidently the commissure of the cerebral parts connected with the vital system.

Reil says that, in man, the anterior commissure may be divided into a body and two extremities; that the body is cylindrical, and at least twice as large as an optic nerve, varying, however, in bulk, like all the parts which resemble nerves; that it consists of bundles of the finest fibrils, which admit of ready separation, when the delicate membrane which invests each and all is divided; that it extends transversely across the brain, from the middle lobe of one side to that of the opposite; [and elsewhere, that centrally it is raised a little, and somewhat inclined backward; that between the fillets of the perforated plate and the pillars of the arch, it extends on either side, through an oval hole, into the anterior striated body; that, plunging laterally into the grey mass of the inner part of the anterior striated body, it passes close below the first bundle of the fibrous cone, or even sometimes is enclosed between its foremost bundles; and that its course is by the anterior extremity of the posterior striated body, between this and the posterior margin of the inner portion of the anterior striated body, and along the neck between both, in which the semicircular line inclines downwards]; that in its course through

the outer portion of the anterior striated bodies, it lies about three or four lines above the cribrous or perforated plate, is extended horizontally in a curvilinear direction, concentric with that of the optic track, inclined somewhat downward towards the base of the middle lobe, directed backwards below the posterior extremity of the hook-like bundles in the entrance of the fissure between the anterior and middle lobes to the point whence its extremity radiates, and, when raised, leaves, for this extent, a distinct and smooth canal.

He also says, that the divergent fibres of the anterior commissure are attached to the inner surface of the hook-like bundles, pass with these to the roof of the inferior horn, and even to the posterior lobe, blending with the general radiation in these parts.

Rolando says that the anterior commissure may be seen either in the ventricles, or from the base of the brain, forming a white cord nearly of the size of the optic nerve; that in passing under the fibres of the peduncles, it gives a bundle of white fibres which go to the anterior lobe; that from this point, bending backward, it traverses the external striated body; that covered then by that substance and almost in contact with the perforated plate, and with the optic track, it runs backward behind the hamular bundles; that escaping from the striated body, it expands

into a plate which proceeds between the fibres of the peduncles and those of the external layer; and that it extends itself upon the posterior and the middle lobe, and reaches even the inferior convolution of the latter. In this description, functional order is throughout inverted; but, this being kept in view, its facts are sufficiently clear.*

It is evident that, in coming thus from behind, it obtains the same relation to the lower part of the posterior, as to that of the middle lobe. In doing so, it presents a remarkable coincidence with the suggestion, that, as the posterior lobe enlarges in proportion to the improvement of hearing and taste, the gustatory nerves may send their cerebral terminations thither. If so, the anterior commissure, by connecting our perceptions from that sense also, will form the commissure of the whole vital cerebral system.

Be this as it may, it is now evident that the inferior lobes of the brain, which have their separate commissure, the anterior one, are subservient to the vital system—are the organ of its perceptions.

It is, therefore, wrongly, that the moral philosophers, as they are called, who know nothing of the structure of the organ and yet write about

* Rolando is of opinion that, by means of fine fibres, the anterior commissure maintains a strict relation with the optic track placed below it.

its functions, assert that nothing can be more certain than this, that it is not by a deliberate choice, *analogous* to what we experience in ourselves, that the lower animals are determined to the pursuit of particular ends, nor by any process *analogous* to our reason, that they combine means in order to attain them.

Now we have already seen that the operations, called mind in man, are far simpler in their elements than is commonly imagined--mere sensations combined, compared and determined, and we now see similar sensations to a more brief extent similarly treated.

The conclusion is obvious, that it is to an abandonment of every known analogy, and strict philosophical induction, that we are indebted for the terms instinct, sympathy, &c.—names invented by craft to shelter ignorance of some of the mental operations, or rather perhaps intended, by giving an air of knowledge, to apologize for trouble, and impose upon the vulgar.

To that unknown principle, says Dugald Stewart, "which guides the operations of the brutes, we give the name instinct. It is distinguished from reason by two circumstances:—1. By the uniformity with which it proceeds, in all individuals of the same species; and, 2. By the unerring certainty with which it performs its office, prior to all experience."

It proceeds with uniformity, because, in the

same species, the organ or action on which it depends is the same. Its certainty prior to all experience is unerring, because its process is brief—it is a single direct and immediate event—the result of an impression on an organ—and having, in many instances, no need of help from experience.

Aqueous vapors, for instance, produce an agreeable impression on the olfactory nerves of a duckling, it follows them to the source of their abundance, plunges into the pool, and swims because it is light and its feathers are oily; while its hen step-mother, which has no such olfactory nerves or oily feathers, calls to it from the bank. Then your moral philosophers open their eyes, look grave, and talk of instinct and of providence, which, thus used, means only their own fooleries.

So they did about the cells of bees, wondering at that admirable hexagonal form by which bodies somewhat circular were in contact without any loss of space, and giving not the bee, but providence and the bee together, credit for surpassing skill, till it was found that all the cells were originally round, and became hexagonal merely by reciprocal pressure, in proof of which the outer ones always continue round.

The infant sucks with its mouth upon the same principle that its intestines contract: both of these operations are regulated by stimuli, and not by instinct or mystery; both are, in the first

instance, equally independent of judgment or volition; the last continues so, while the first becomes more and more dependent on the will.

The first part of this argument with regard to the original excitement of these actions by mere stimuli, seems to have been overlooked by philosophers, although it is, in reality, the only very important part of the argument. Our improvement in these actions by experience, however, is well supported in the following passage.

"The celebrated Harvey," says Dr. Darwin, "observes, that the fœtus in the womb must have sucked in a part of its nourishment, because it knows how to suck the minute it is born, as any one may experience by putting a finger between its lips, and because in a few days it forgets this art of sucking, and cannot without some difficulty again acquire it, (Exercit. de Gener. Anim. 48). The same observation is made by Hippocrates.

"A little further experience teaches the young animal to suck by absorption, as well as by compression; that is, to open the chest as in the beginning of respiration, and thus to rarify the air in the mouth, that the pressure of the denser external atmosphere may contribute to force out the milk.

"The chick yet in the shell has learnt to drink by swallowing a part of the white of the egg for its food; but, not having experienced

how to take up and swallow solid seeds, or grains, is either taught by the solicitous industry of its mother; or, by many repeated attempts, is enabled at length to distinguish and to swallow this kind of nutriment.

"And puppies, though they know how to suck like other animals from their previous experience in swallowing, and in respiration; yet are they long in acquiring the art of lapping with their tongues, which, from the flaccidity of their cheeks, and length of their mouths, is afterwards a more convenient way for them to take in water."

SECTION IV.

STRUCTURE AND FUNCTION OF APPARENTLY DESCENDING PARTS.

In this system, as in the two preceding ones, we have descending as well as ascending columns.

Reil, whose mere order of description I invert, states, that two cylindrical bundles join the posterior striated bodies above the ansa of the anterior peduncles of the cerebel;—that one passes on either side of the central groove of the lozenge; that these are half medullary or white, and simply covered with epithelium; that they are broadest in the centre of the lozenge, and are contracted below as well as above;—that they ascend from as low down as the crossing of the pyramids.

In this description, the most striking circumstance is the correspondence of these bundles in structure—*their being half medullary or white, like the ascending bundles of this same system already described, and indeed like all the nerves of the vital cerebral system.*

Elsewhere, Reil says that, at the floor of the passage between the third and fourth ventricles; the cylindrical bundles are placed; and that below these is the ansa of the anterior peduncles of the cerebel; and then, the remaining mass of the peduncles of the brain. Thus above this ansa, is the course of the cylindrical, and below it, that of the vertical bundles.

Thus both the ascending and descending bundles of this system, of which the former run below and the latter above the ansa of the anterior peduncles of the cerebel, and which so closely resemble in structure both to each other and to the nerves of this system throughout the body, pass clear of the cerebel and its ring. In this respect, they resemble the lateral or olivary bundles belonging to the system of involuntary muscular action; and it is now, under the expansion of these bundles in the tubercles and in the deepest part of the brain, that their central portion is placed.

That life is dependent on this portion is proved by any injury to it instantaneously extinguishing life.

It is in connexion with these, doubtless, that, as Magendie says, the interior and sides of the fourth ventricle have a vivid sensibility.

Thus the central part of the bundles on which life is dependent is exquisitely susceptible of pain; and it is probable that, on its branches alone, that feeling is dependent. As the descending bundles of this system pass down the posterior part of the spinal cord, their susceptibility of pain may have helped to mislead Sir C. Bell and his followers.

Reil says, that at the entrance of the fissure between the anterior and middle lobes, an obscurely organized substance, the medulla incognita, occupies this surface in the base of the brain; that it is continuous before with the posterior striated bodies, laterally with the greater bend and fimbriated body, and thus encircles the outer margin of the cerebral peduncles, being exposed on the removal of the optic tracks [to which it is somewhat parallel]; that it adheres to the outer margin of the tracks; that it contains part of the anterior commissure; and that from it white fibrils, every where mixed with grey matter, are given off, which pass, like teeth, into the pecten.

Many observations I have already made indicate its belonging to the vital cerebral system.

CHAPTER VII.

STRUCTURE AND FUNCTIONS OF THE CEREBRAL NERVES.

Of the forty-four pairs of nerves belonging to the human body, thirteen are directly connected with the brain, and thirty-one with the spinal cord. The former are called cerebral; the latter, spinal nerves.

LAWS OF ORIGIN AND TERMINATION.

The laws according to which these nerves arise and terminate, are of primary importance.

It has been remarked, that nerves connected with the functions of any one organ, are generally connected with the same part of the brain and spinal cord. This, however, is not true; unless we understand "the same *external* or *superficial* part of the brain and spinal cord," the mere *apparent locality* of connexion.

Thus, in the spinal cord, the nerve of sensation and that of motion are to be found in the two roots arising together.

Thus the smaller portion of the former fifth, as observed by Mr. Mayo, rises from the upper part of the oblong process close upon the greater

portion; and accordingly the sense of pressure upon the teeth and gums depends upon the latter; the muscular effort itself, upon the former.

Thus the facial nerve rises near the auditory; and accordingly the expression of passion depends upon the former; and the sense of hearing, so intimately connected with passion, upon the latter.

This, however, is but a superficial view: it is necessary to consider the matter more deeply.

Nerves of the same sense arise in similar external structure; as those of touch in the skin.

Nerves of the *same sense* in the *same part* arise together even from the same points; as the sensitive origins of the trifacial and facial from the same points of the skin of the face; even though, being nerves of different character (of vital and mental sensation) they terminate in different parts of the brain.

Those who thought one of these a nerve of sensation, and the other a nerve of motion, were grievously puzzled by finding their fibres united on the skin. The difficulty vanishes when we see that it is as means of sensation, that both arise together in the same points of a sensitive organ, and that it is as vital or mental, that each terminates in a different part of the brain.

Nerves of different sense arise from different

external structure; as the optic and auditory, or as even the tactual, olfactory, and gustatory origins of the trifacial, from the skin, the pituitary membrane, and the tongue.

Nerves of sensation have generally, if not always, these three terminations:—

1. A perceptive termination in the free expansions, or septa, vela, &c.;

2. A ganglionic termination, connected with involuntary action;

3. A convolutional termination, connected with voluntary action.

Nerves of motion have always one of these three origins:—

1. An origin from involuntary bundles;

2. An origin from voluntary bundles;

3. An origin both from voluntary and involuntary bundles.

Nerves of motion arise from cerebral involuntary, or voluntary parts, or both, according to the character of the organ which they supply, or the varying character of the action it may, under various circumstances, perform.

Nerves of different character often come into contact at the surface of the brain and spinal cord for the mere convenience of accompaniment and distribution. They must not on that account be reckoned one and the same; as the auditory and facial were formerly, or as the trifacial and masticatory are at present.

THE OLFACTORY NERVES.

In fishes, reptiles and birds, the olfactory nerves, or first pair, which are evidently the nerves of smell, terminate in the anterior masses of the brain; and a white stria connecting these corresponds to the anterior commissure.

In mammalia, the olfactory tubercles are united together by a bundle of fibres belonging to the anterior commissure and running forward in an arched shape.

In herbivorous animals, this nerve sends a superficial white bundle backward to the depression between the anterior and middle lobes. This portion is distinctly separated from another bundle of the nerve running above it, by a thin layer of brown matter. Both these bundles run backward and outward so as to leave a wider space between their posterior than anterior parts. Superiorly and somewhat anteriorly to these, a third bundle runs first inward and then upward between the anterior lobes, where it approximates to the anterior commissure, the thin partition, and the external mesial expansion.

In man, these nerves have similarly three terminations.

Their outer white termination passes outward backward and upward, disappearing externally

at the farthest part of the anterior lobe, where it joins the middle one, spreading there sometimes into two or three white filaments. Pfeffinger,* says the external termination is in the angle of the fossa of Sylvius—" ex Sylvii fossae angulo ;" and in this all agree.

Their middle grey termination, which, however, presents white substance internally, appears to pass upward by the side of the third ventricle, toward the posterior tubercle of the same side. It is of this termination that Gall and Spurzheim, reversing functional order, say that the white track which comes from the posterior tubercle, divides the first at the internal geniculate body, and seems to slip under it, to cross it in passing forwards ; that therefore they do not believe that it belongs to the optic nerve ; that they have even for a long time thought that it forms the external root of the olfactory, which is indeed very nearly in that direction ; but that they have never been able to trace its continuity. In confirmation of this termination, it has been observed that both the posterior and the internal geniculate body are larger in carnivorous than other animals, and that in them also the sense of smell is most acute. But, on the other hand, it is objected that dolphins and porpoises, which have no olfactory nerves, have nevertheless very

* De Structura Nervorum.

considerable posterior tubercles. These, however, may be mere vestigia, as the nipples in man, or the rudiments of feet concealed under the skin in the anguis, typhlops and amphisbœna. It is remarkable that it is this middle root of the olfactory nerve that gives fibres to the bundle which comes to the anterior commissure from before.

Their inner white termination seems to pass toward the anterior commissure, thin partition, and external mesial expansion.

Of all these roots, Malacarne says "longius filamentum a nervoso funiculo promanat, qui sursum provehitur per tertii ventriculi latera lanugine cinerea obtectus. Minus filamentum persaepe a fine eius tractus medullaris, qui commissurae cerebri anteriori continuus est, producitur, ubi nempe is tractus gibbam et inferiorem corporis striati faciem perfodit. Tertium denique filamentum a medullari cerebri corpori striato circumposita proficiscitur ad imum sulcum, qui cerebri lobos dirimit, ubique prioribus sociatur."

Thus this nerve of sense has three terminations: the first passing to its perceptive organ, the middle lobe; the second, toward the bundles connected with involuntary muscular action; and the third, toward the thin partition and its sensorial expansion. — There are reasons for

supposing that other nerves of sense have corresponding terminations.

THE OPTIC NERVES.

The optic nerves, or second pair, which are evidently the nerves of vision, appear also to have three terminations, which shall be considered in the opposite order to those of the olfactory.

Their first termination, which, though often described, has never been regarded as such, so evidently ascends from their commissure toward the same point with the last mentioned termination of the olfactory, that its not having been viewed in its true light is really surprising.

Reil, as usual reversing functional order, observes, that, at the fore part, the thin partition begins by the meeting of either layer of epithelium upon the anterior commissure; that the base of this partition is formed by its extension from this point to the bend of the superior commissure, and corresponds with a linear furrow seen on the base of the brain between the fillets of the perforated plate; and that, from the posterior extremity of this furrow, which immediately touches the anterior commissure, a delicate membrane extends to the optic commissure. And elsewhere he states, that a thin *layer of nervous matter* is continued from the

furrow [of the thin partition] and posterior margins of the fillets, to the optic commissure.*

This termination appears also to pass to the internal mesial expansion.

Nothing, then, can be clearer than that, in this termination toward the lateral ventricle, the optic surprisingly resembles the olfactory nerve.

The next termination, in the superior tubercles, is now universally recognised.

Tiedemann says that, on dissecting the brain of a fœtus of the latter end of the third month, he discovered the optic nerves, and succeeded in tracing them into the interior of the tubercles, as also to the surface of the optic chambers; and that he had frequently repeated the same observations in more advanced fœtuses of four and five months.

Accordingly, in those animals which have large optic nerves, the superior tubercles are of larger size; in individuals in which the optic nerve of one side is weakened and thinner, it is sometimes found that the corresponding tubercle is also smaller; by injuring the optic tubercle of one side in pigeons, blindness of the opposite eye ensues; and by dividing one optic nerve, the under surface of the opposite tubercle, to

* Since writing this, I find that Vicq d'Azyr expressly states this to be a termination of the optic nerve.

which the nerve adheres, is found in a few weeks to waste.

But though the optic nerves may thus seem to terminate at the involuntary organs, they doubtless ascend to the hemispheres; for even the nerves of common sensation do so by the pyramidal bodies, as all allow, and the olfactory nerves, as we have just seen, send not only one termination to the middle lobe but others to other parts.

Another, a third, or cerebral termination of the optic nerve has in fact been described by anatomists who did so without being aware of it; and this oversight has arisen chiefly from their reversing functional order in this, as in other cases.

In all quadrupeds, say they, the principal bundle of the optic nerve goes from the upper tubercles to the external geniculate body. And as to man in particular, Cuvier's report on Gall and Spurzheim's paper says "The medullary track which comes from the nates, meets in its course the tubercle called corpus geniculatum externum."—Now, it is evident that nerves of sensation pass to and not from the brain; and attention to this would have prevented anatomists speaking of the nerve coming from the tubercle and going to the geniculate body, and being reinforced there—instead of being diminished there, before its remaining portion reaches the

tubercle. This fact I hold to be decisive; and it shows the importance of physiological order.

Tiedemann, however, speaks of these as two roots, saying he considers the tubercles and geniculate bodies as the principal roots of the optic nerves, without, however, asserting that they are the only ones.

In fact, the superior tubercle and the external geniculate body form on each side two different terminations; and as the former is that ending in the involuntary muscular apparatus, the latter is that ending in the cerebrum by means of its peduncles.

Reil observes that the geniculate bodies are globular, grey behind, white before, and expand themselves over the peduncles of the brain, especially along their outer margin; and that, at the outer margin of the posterior striated bodies these structures blend in the pecten, which is thus a texture woven of the cerebral peduncles and posterior striated bodies.

Now, as the external geniculate body receives fibres from the nerve, and as the geniculate body sends its fibres to the peduncles, pecten, and consequently the fibrous cone, it becomes evident that the optic nerve has this last termination in the hemispheres — the removal of which therefore may well be injurious to vision.

Hence Magendie observes, that "the action of the optic apparatus is almost always united to

an intellectual or an instinctive operation. Hence Flourens says that when both lobes of the brain are removed, the animal becomes blind. Hence the reporters to the French Institute on the enquiries of M. Flourens also conclude, that the integrity of the cerebral lobes is necessary to the exercise of sight.

The injury of vision by the removal of the hemispheres, when added to the preceding facts, not only proves that the optic, like the olfactory nerves, have roots in that portion of the brain; but, as in this case, the removal of the right hemisphere affects the left eye, and vice versa, it shows not only that the influence is specific, but that the optic image has crossed to each hemisphere respectively.

It remains now to notice the commissure or meeting of these nerves.

Among fishes, the right optic nerve of the skate goes through a fissure in the left. In bony fishes, one nerve merely lies on the other. —In reptiles, the optic nerves cross; in some, without any union; in others, first intermixing. —In birds, the optic nerves arise from the fore part of the anterior cerebral masses, and form a perfect decussation near the infundibulum. In birds of piercing sight—falcons, king-fishers, cranes, &c. the optic nerve presents plicæ which are continued into the retina and increase its extent.

In mammalia, the decussation of the optic nerves is less obvious than in the preceding classes; but still it exists, and indeed the junction of the two nerves at that point distinctly announces the purpose.

With regard to the optic nerve generally, it appears, that the outermost fibres of the optic track form also the outermost of the optic nerve of the same side; that the next in order cross over to the optic nerve of the other side; that the innermost fibrils of the track on one side, are continuous with the innermost fibrils of the opposite, forming an internal or posterior loop; and that the innermost fibrils of either optic nerve form an external or anterior loop.*

Where the eye of an animal has been destroyed or injured, the optic nerve is found to be altered in structure and appearance as far as the union; and beyond that the alteration sometimes extends along the opposite nerve. In birds, injury either of the eye or of the superior tubercle, extends diagonally to the opposite side.

* Vicq d'Azyr and Ackermann observed that the external fibres of the optic nerve are continued on the outside of the optic track; and the Wenzels, making the same observation, added that the internal fibres are directed obliquely to the other nerve. The 1st figure of their 6th plate, moreover, shows the posterior loop formed behind the junction or between the optic tubercles.

In mammalia, which have the eye in a rudimentary state, the 2d, 3d, 4th, & 6th pairs are wanting, and the nerve entering the eye is a branch from the ophthalmic branch of the trifacial. Nevertheless, the mole, shrew, mus capensis, and proteus see more or less. In the proteus anguinus and cœcilia, a branch of the trifacial supplies the place of the optic, which, as well as the 3d, 4th, and 6th, is wanting.

Thus this nerve of sense has also three terminations: one passing from the external geniculate body to its perceptive organ; another, toward the bundles connected with involuntary muscular action; and a third, toward the thin partition and its sensorial expansion.

THE GENERAL OCULO-MUSCULAR NERVES.

The general oculo-muscular nerves, or third pair, first appear externally on the cerebral peduncles towards their internal edge; their roots being there arranged in a line, nearly in the direction of the peduncles, and the posterior being the longest.

Where each nerve touches the perforated brown space between the peduncles, it receives filaments from it; and these seem to me to descend to it from the vicinity of the anterior tubercles, along the side of the posterior striated body and between the peduncles. Hence it is

that, in fishes, this nerve arises from the ganglion of the cavity of the tubercle.

Another part of the roots may be traced above the transverse ring, as coming, I suspect, from the cerebel itself.*

Malacarne first described an origin, alluded to in the last foot note, which he deemed an accessary to the third, and which descends from the involuntary bundles near the origin of the internal oculo-muscular nerve.†

* Malacarne in his *Nevroencefalotomia*, p. 169, says "Dalle pareti convergenti dell' antro escono molti filetti midollari, quasi altrettante setole di morbido pennello, e tali filetti sono distinti in tre ordini da due tenui lastre midollari orizontalmente frapposte a cadun ordine. I due ordini superiori ho potuto seguitarli da entrambi i lati fino alla profondità di due linee e mezzo nella sostanza delle pareti dell' antro, e ne ho veduto le fibrille disposte a raggi scorrere oblique in fuori, e in dentro, e perdersi nella fosca sostanza interna della colonna midollare centrale. L'ordine inferiore alcune volte piegasi notabilmente verso il margine interno degli archi onde sono abbracciate le gambe del cervello, ed ivi essendo le fibre poco profondamente nascoste vengono avvalorate da un cordoncino midollare composto or di due, ora di tre fili nervosi, che io nomino nervi accessorii dei motori comuni degli occhi.

† "Ho talvolta veduto quattro, sei, e fin otto filuzzi, dei quali ora due, ora tre per lato vidi a salire verso l' origine dei nervi patetici, tra i fiocchi (curvandosi in alto) e le vicine braccia del cervelletto; indi scorrendo, sul lembo superiore del velo midollare piantarsi nella sostanza donda i patetici medesimi hanno origine."—*Delle Osservazioni in Chirurgia Trattato*.

This nerve, which, conformably with its origins, seems to be one both of involuntary and voluntary motion, is distributed to muscles of the eye, with the exception of a small twig which assists in forming the lenticular ganglion.

THE INTERNAL OCULO-MUSCULAR NERVES.

The internal oculo-muscular nerves, or fourth pair, appear externally to arise transversely from the anterior edge of the free expansion behind the posterior tubercles.

It seems properly to have but one origin, sometimes by several filaments, which may be traced under the posterior tubercle.

The frenum of this thin expansion seems sometimes to form a commissure for this pair.

This nerve which, conformably with its origin, is one of involuntary motion, is distributed entirely to one muscle, the superior oblique of the eye; and its influence over it is seen in involuntary affections, dying, &c.

THE EXTERNAL OCULO-MUSCULAR NERVES.

The external oculo-muscular nerves, or sixth pair, appear externally between the transverse ring and the pyramidal bodies, sometimes near to the olivary bodies.

Malacarne observes that, in some brains, there appear externally to be three roots of this nerve—one from the upper part of the white bundles covered by the inferior margin of the cerebellic

ring; another from the same bundles where they are free from the ring; and a third from the outer side of these bundles.

Pfeffinger describes two externally apparent roots. The smaller and internal, he says, arises from the lower edge of the transverse ring chiefly; the thicker and external, from between the transverse ring and the pyramids.

Internally, this nerve appears to have only one connexion, and that is with the cerebel, from which it descends in very fine filaments through the oblong process to these externally apparent origins.

This, I first, I believe, pointed out in July, 1809.—See Archives, &c.

Consistently with this, it is a nerve of voluntary motion, supplying the external straight muscle of the eye—a muscle which seems to me always to act with the will.

THE TRIFACIAL NERVES.

The means of the lower or vital sensation, and of involuntary motion, in the face.

The trifacial nerves, or fifth pair, appear externally to emerge from a fissure of the transverse ring.

As this is a complex nerve, it has various connexions with the brain.

Soemmerring points out a connexion of it

with the cerebrum and with a bundle at the floor of the fourth ventricle. He says "ex ipsis cerebri processibus medullosis, quid quod ex ipso fere ventriculi quarti pavimento oriri videatur." Few will doubt his accuracy on such a subject; and indeed to do so because other terminations or origins have been observed, would be wrong after the multiplication we have already seen of these even in the case of simple nerves.

That it has thus a cerebral termination will readily be allowed by those who deem it a nerve of conscious sensation, who are now satisfied that such a nerve must ascend to the brain, and who, even by means of the rudest method of examination, observe its close approach anteriorly to the cerebral peduncle.

In confirmation, however, of its further connexion—origin it must be called, Reil observes that, "where the lateral and posterior peduncles of the cerebel meet at the broadest part of the floor of the fourth ventricle, the small triangular chamber exists, into the grey substance contained in which the roots of the facial and of the trifacial sink, and perhaps those of the eighth," and as this is in immediate contact with the descending portion of the fillet or olivary bundles, on which involuntary action depends, —as the nerve descends upon it and in the course of its fibres,—it seems highly probable

that this nerve, which supplies so many involuntary parts, thence receives an accession.

It has still, however, another termination first pointed out by Santorini, namely near the olivary bodies.*

Gall and Spurzheim also trace this origin to between the olivary and restiform bundles.

Finally, Tiedemann says, that, at from fourteen to fifteen weeks, he traced the trifacial across the transverse ring to its posterior part, where it formed a small swelling in the spinal cord, between the restiform body and middle bundle, on the surface of which is subsequently developed the olivary body.

It seems to me probable, from the direction of the fibres of the nerve, which are partially seen in Niemeyer's plate, in the eleventh volume of Reil's Archives, that this ganglion has a relation to the third division of the greater portion of the nerve, which sends a branch to the tongue, and that, in it, this branch is especially connected with the involuntary system, as are the terminations of the optic, &c. in the tubercles above.

The other involuntary actions or influences of

* Hunc igitur sum prosecutus, unde in interiorem medullæ oblongatæ caudicem conjectus fere inter ollivalia et pyramidalia corpora locatus, quo demum pergeret, cum tenuium fibrarum implexus, tum earumdem mollitudo, ne consequerer omnino prohibuere.—*Tabulæ Septemdecim*, *p.* 16.

this nerve may be connected with the great ganglion or plexus which it forms previous to its division.

In the Preface, I pointed out the errors committed by Sir C. Bell and Mr. Mayo as to the fifth pair of nerves, and also the seventh. I there showed that "*on the ganglionic portion of the trifacial nerves, vital and involuntary motions depend*" (p. 119, &c.), and that *the facial nerves are* "*at once nerves of conscious sensation and of voluntary motion*" (p. 125, &c.) Since that was printed, there has appeared in the No. for July of the Edinburgh Medical and Surgical Journal, an account of a dissertation by Bellingeri, published in 1818, in which it appears that he established the same conclusions as to these two nerves sixteen years ago.

These conclusions were indeed sufficiently obvious to every man capable of reasoning. Yet as it pleased Sir C. Bell to borrow a portion of my more general doctrine, to invert and mutilate it, to *make it so far not mine*, and therefore to *call it his own!* so it pleased him to borrow this more limited doctrine of Bellingeri as to these two nerves, to mutilate and adapt it to his work, to *make it so far not Bellingeri's*, and therefore to *call it also his own!*—Thus are his papers composed! and thus is their plagiarism defended!

But to return to the subordinate consideration

of the trifacial nerves (I say subordinate, because they are shown, both in the Preface to this work, and in the long preceding dissertation of Bellingeri, to have no analogy of structure or function to the spinal nerves, as it suited Sir C. Bell to assert)—to return to the trifacial nerves, I shall now, profiting by the account of the Journal above mentioned, notice Bellingeri's opinions in his elaborate Dissertation, in order to give a fuller view of the functions of these nerves, than, without a knowledge of its existence, I had given in the Preface. I shall, at the same time, point out the errors he appears to me to commit in his reasonings respecting them.

The trifacial, as a sensitive nerve, receives branches from the whole of the skin of the face and head, from part of the organ of smell, and from the tongue. As a nerve of involuntary motion, it gives branches to all the glands, viz. the lacrymal gland, the tonsils, all the salivary glands, and the mucous glands of the nose, mouth, and ears; to the mucous membrane of the nose and its sinuses, of the tongue, palate, mouth and upper part of the pharynx, the external conduit of the ear, and the periosteum; to the iris, the muscles of the tongue and palate, and to all the facial muscles—in short, to every part of the face.

That the trifacial is a vital nerve, Bellingeri

shows, first from its origin and structure. It appears, he observes, to spring chiefly from the olivary body, viz. from a sort of ganglion; and in its structure, it resembles closely the nerves of organic life, by the interlaced arrangement of its filaments, the universal presence of ganglia upon all its considerable branches, its repeated anastomotic communications, the occasionally augmented size of its parts, as in the trunk, in the ciliary nerves, in the external nasal, and in the posterior palatine nerve, which establishes a similitude between it and the intercostal, and by its being uniformly accompanied by arteries —a remarkable proof of connexion with the functions of vitality.—He might have added that it sinks into the middle cavity of the basis of the skull, in which all are vital parts.

The sensitive faculty of the trifacial nerve, Bellingeri illustrates in various ways.

Distinguishing the sense of touch into two modifications, of common touch, and a more refined tact, he admits that the former is entirely guided by the trifacial; but he ascribes the latter to the numerous, repeated, and multiplied inosculations of the trifacial with the facial nerve.

This is generally speaking correct; but it nevertheless involves something erroneous, or perhaps I should say, not understood, and unexplained. There is no difference between the touch and tact here spoken of, except that the

trifacial nerve ascends to vital bundles, and the facial to intellectual ones.

The sense of smell, Bellingeri distinguishes into animal smell, properly so named, exercised by the will, and natural or instinctive smell, exercised independently of the will. The first he regards as under the influence of the proper olfactory nerves; and the second as performed by the filaments of the fifth pair.

This also involves an error. The will may direct the senses; but it can have nothing to do with their intimate nature. That, as observed in the former case, must here depend on the trifacial nerve being connected with vital bundles, and the proper olfactory with intellectual ones. The smell dependent on the olfactory nerve is, I believe, connected more especially with respiration; that which is dependent on the trifacial, with the use of food.

As to the sense of taste, Bellingeri remarks that the tongue derives nerves from four different pairs, viz. the glosso-pharyngeal, the hypoglossal, the lingual branch of the fifth, and the seventh pair. He thinks that the twig from the latter, denominated chorda tympani, supplies not only the animal sense of taste, but partly the voluntary motion of the tongue; and he remarks, that this arrangement is in accordance with that of the other organs of sense, in which we find a double nervous system, one of the proper sense

peculiar to the organ, the other performing certain common sensitive functions of the organ.

The error here is still greater. Bellingeri misleads himself by a false analogy. He thinks that, as sight and hearing have peculiar nerves, so must taste; but he fails to see that, while these are higher senses, taste is the peculiar sense of the vital system, and should therefore exclusively belong to the nerve which is peculiarly appropriated to it. This nerve, the trifacial, is in fact the means of all the chief sensitive faculties belonging to that system—of its touch, as he himself shows, in the face, of its smell as has just been observed, and of taste, which is exclusively its function. The general analogy would have been broken, and a mere anomaly presented, if taste had not been exercised by the trifacial nerve. This is accordingly established both by physiological and pathological observation. The chorda tympani is a mere connecting twig.

I mainly agree, however, with Bellingeri as to the sensitive functions of the trifacial nerve, and only wish to point out the subordinate errors he commits as to its sensitive faculties. He reasons more accurately as to its motive faculties.

He justly argues that the influence of the fifth pair over all the secretions, viz. the lacrymal, that of the Meibomian glands, the mucous secretion of the pituitary membrane of the nostrils, the

salivary secretion of the sublingual, maxillary, and parotid glands, the mucus of the muciparous follicles of the palate, mouth, cheeks, tongue, lips, and tonsils, and even the cerumen of the ears, as well its supplying the maxillary, sphenoidal, and frontal sinuses, the teeth, the internal parts of the ear, the pharynx, and periosteum, shows that it performs only functions proper to vitality.

He reasonably maintains that its constant association with the minute arteries of the face regulates the circulation of that part of the body; and that all the change which the colour of the cheeks undergoes in shame, rage, terror, indignation, horror, joy, hope, and desire, are to be attributed to the influence of the fifth pair over the facial capillary circulation—a view which is far more reasonable than, and indeed utterly destructive of, the notion of Sir C. Bell, that all these are dependent on the facial nerve; for the trifacial extensively supplies vital and involuntary parts, and the actions in question are altogether of this character, while the facial, as even he grants, is a voluntary nerve!

That the trifacial is a nerve of involuntary action is rendered equally evident when it exclusively supplies muscular parts. The motions of the uvula, velum palati, and upper region of the pharynx, are all, as Bellingeri observes, involuntary and instinctive, and we find that these

parts, and the circumflexus and the levator palati, are all supplied by the palatine nervous filaments of the fifth pair. He shows, accordingly, that though mastication and deglutition be in some degree voluntary motions, those of the uvula, palate, and upper division of the pharynx are entirely involuntary, and accomplished without effort or consciousness of the individual.

Even when the trifacial nerves supply the parts about organs of sense, Bellingeri shows that the vital part of the properties of the organ depends on them; and the mental, on the proper nerves sent to the organs.

The iris, he observes, derives its nerves from the ophthalmic ganglion, which is formed by the trifacial in conjunction with the general oculo-muscular nerve. In some rare instances, he observes, the motion of the iris has been found to be dependent on the will, and in these, he shows, that the ciliary nerves received no branches from the fifth. It is also he observes, known that, in certain species of animals, as the parrot, owl, and the rays, the circumstance of the iris being under the will of the animal is connected with the want of the ophthalmic ganglion.

The involuntary motions of the internal ear he, in like manner, attributes to the anatomical fact, that the chorda tympani consists of fila-

ments of the lingual branch of the fifth pair extended over the cord, and to the associated fact, that the muscles of the stapes and malleus receive no branches from the seventh pair, until the latter has been formed by the petrous branch of the vidian nerve of the fifth pair, after which it immediately distributes the appropriate filaments to the muscles specified.

As to the motions of the tongue, he observes that the various nervous sources from which it is supplied, are connected with the various functions assigned to it. He observes that the tongue performs a mixed class of motions, which are sometimes voluntary, sometimes involuntary; the involuntary or instinctive motions being those exhibited in sucking, mastication, deglutition, and crying, in which the tongue assists, and which the new-born infant exercises instinctively. The lingual branch of the trifacial, he observes, contributes to the involuntary motions, since it sends filaments to the internal pterygoid, the mylo-pharyngeus, the stylo-glossus, the lingualis, and the genio-glossus, giving these muscles some degree of an organic and involuntary character.

From all this, Bellingeri concludes, that though, on the trifacial emerging upon the face, above and below the orbit, at the temples, in the region of the cheeks, and at the mental hole, its filaments are immediately conjoined with those

of the facial by anastomosis so close as to constitute almost one nerve, yet so far as the trifacial itself is distributed to the muscles and integuments of the forehead, nose, lips, mouth, and face generally, it contributes only to involuntary or organic actions, and the voluntary motions depend on other nerves.

He repeats, at the same time, the observation made by Gall, that the trifacial nerve is more developed than all the nerves of the head in new-born infants, and that, even in the lower animals, its size is proportionally greater than in the human subject. The life of the fœtus, then, being entirely organic, and that of brute animals as it affects the face making a nearer approach to instinctive or organic action than in the human subject,—he shows, that this circumstance also is in favour of the influence of the trifacial being of that kind denominated organic or involuntary.

In this manner, Bellingeri shows that the trifacial nerves, whether they preside over organs of sensation, circulation, secretion, or more conspicuous motion, perform functions which are invariably independent of the will, and are to be regarded as strictly organic, and consequently that these nerves regulate all those actions, whether sensitive or motive, which are independent of the will. All this is to be understood, he adds of that which has been called

its larger, plexused, or ganglioned portion only.*

THE MASTICATORY NERVES.

That this nerve has a cerebellic origin, as stated by Santorini, Wrisberg, Soemmerring, Scarpa, Girardi, Palletta, &c. will readily be expected by those who observe, that it is a nerve of volition, and who are now satisfied that such a nerve must descend from the cerebel.†

* Statuam igitur, quintum par nervorum esse sentientem et motorium vitae organicae in capite. Quae de quinto pari generatim diximus, de ipsius portione majori tantum intelligenda.—P. 175. XXXVII. This, however, is a distinct nerve; and I have here considered it as such.

† Of this nerve Santorini says he had discovered "saepius, ubi firmioria cerebra offendisset, tenuiorem fibram seorsum paulo supra emergere, ac mox caeteris copulari." Girardi says "faciculum minorem *non ab eodem cum caeteris exoriri loco certum est*. . .ubi ad majorem accessit, copulari quidem videtur, sed revera sic adjungitur, ut cum eodem procedens distinctus tamen. . .ut *diversum iter instituat, et diversam naturam præsefert*." Palletta, correcting an error of Girardi as to distribution, says "Mihi autem iteratis dessectionibus compertum est, non modo *eas fibras ex eodem trunco non procedere*, sed, licet, *a diverso principio constanter procedant*, et perpetuo reperiri, et a retiformi plexu esse distinctas, et una omnes ad maxillarem inferiorem contendere." And, speaking of this and the branch he calls buccinatorius, he says "*horum nervulorum fibrae diversam omnino naturam praeseferunt;* nam multo sunt candidiores et robustiores iis, quae quintam faciunt conjugationem." He

Its apparent origin is just above the trifacial, exactly opposite to the commencement of the inferior peduncle of the cerebel. Its structure entirely differs from that of the trifacial; its filaments being whiter, thicker and stronger, and presenting the common aspect of other nerves. It forms neither semilunar plexus or gasserian ganglion, nor is invested by the bracelet described by Malacarne as surrounding the trifacial. It bends, in its course, from above, forward, downward, and backward around the trifacial. It is distributed to the chief muscles concerned in mastication.

Bellingeri observes that this nerve evidently regulates the movements of the temporal, masseter, buccinator and pterygoid muscles, as well as the orbicularis labiorum, elevator anguli oris, and triangularis menti, to which it is distributed.

As it has nothing to do with sensation like the trifacial, and is altogether a motory nerve, he has given it the denomination of Nervus Masticatorius.*

adds "quum igitur extra omne dubium positum sit nervos nostros: *non solum ortu differre*, et, ut infra ostendemus, filamentorum distributione, sed incessu etiam a reliquis esse separatos, *oportet sane, ut inter nervos peculiari loco recenseantur, et propriis etiam nominibus distinguantur.*"—PALLETTA, *De Nervis crotaphitico et buccinatorio.*

* Spectat igitur portio minor ad nervos vitæ animalis, et

It appears, in certain parts, to preside over involuntary motions: thus the buccinatorial branch, not only regulates the movements of the buccinator muscle, but transmits filaments to the duct of Steno and the buccal glands; but this, as Bellingeri shows, is owing to its receiving filaments from the inferior maxillary branch of the trifacial nerve.*

quidem ad nervos motorios; nullibi enim sensibus praeest; et habita ratione ipsius officii Nervus Masticatorius esset dicendus. Of the function of these nerves, Palletta had previously said "Illud tamen videtur certum, praecipuam eorum actionem esse in partes a voluntate motas."

* Verum demonstrato, prout sategimus, minorem hanc portionem per se voluntarios exequi motus, inquirendum remanet, cur in quibusdam circumstantiis involuntarie vel ab instinctu moveat musculos in quibus inseritur. Then follows, as observed by the Edinburgh Reviewer, the very explanation given many years afterward by Mr. Mayo. "Hoc pariter anatomes explicatur adjumento; vidimus porro in præcedenti dissertatione minorem quinti portionem in suo e foramine ovato egressu, intime ut plurimum per plexum ganglioformem cum maxillari inferiori connecti, insuper et fere omnes ramos portionis minoris accipere radices aut filamenta a ramis maxillaris inferioris; igitur portio minor in propriis ramificationibus est nervus compositus ex propriis filamentis et a filamentis maxillaris inferioris. Nil mirum inde, si voluntarios ut plurimum et modo etiam involuntarios exequatur motus, quos tamen producit non per propria filamenta, sed per ea quae a maxillari inferiori proveniunt, quem organicae vitae præesse, et involutarios perficere motus ex superius dictis constare dijudico!"—P. 178.

THE FACIAL NERVES.

The means of the higher or mental sensation, and of voluntary motion, in the face.

The facial nerves, or seventh pair, appear externally between the restiform and olivary bodies, in two distinct portions, as observed by Soemmerring.

Those desirous of beholding the real course of the nerve, need only make, close to the side of its externally apparent origin, a longitudinal incision, through the oblong process, toward the floor of the fourth ventricle, and they will then see it to be there about the thickness of a crow's quill, strong, shining, and throughout formed of two perfectly distinct cords. Of these cords, one is rather anterior and larger; the other, rather posterior and less. Both thus pass through the substance of the process, in close contact, and are, in their course, inclined toward the centre of the substance through which they pass. Both appear to reach a small pit situate somewhat laterally in the bottom of the fourth ventricle; and, there, the anterior seems to pass forward to the brain; the other, backward to the cerebel. The anterior, therefore, is probably its cerebral; the posterior, its cerebellic portion.

This, I first, I believe, pointed out in July, 1809.—See Archives, &c.

Consistently with this, the nerve is at once one of sensation and one of motion.—It is accordingly of this nerve, well known to be a voluntary one, that Magendie observes, as to its sensitive faculties, that, "if we may judge from the struggles and cries of the animal, the nerve is *very* sensible!" Müller makes a similar observation.

In the dissertation already alluded to, Bellingeri adduces evidence to show that the facial nerve presides over the mental or animal functions of the head, face, and neck, that is to say, over sensation and motion, as intellectual and voluntary faculties.

In favour of this fact, he adduces its origin, principally from the ascending white bundles and the restiform body, and its anatomical peculiarities, in which it altogether resembles the nerves of the higher functions. Thus it nowhere forms ganglia; it has a common structure with the nerves of higher function, by remarkable plexuses and frequent anastomotic communications; and it is inserted almost entirely into the skin and muscles.

As it is distributed to the skin of the head, face, and neck, and to all the muscles of the external surface of the head, excepting the temporal, into the stylo-hyoid, and the posterior part of the digastric and the platysma myoides, it must, says Bellingeri, be considered as pro-

bable, especially after what has been stated already regarding the facial, that the higher sense of touch and the voluntary motion of the muscles of the face, depend on the influence of this nerve.

All this is perfectly consistent with this nerve's possessing that double origin which I have described above, and which, as has been seen, I published nine years before the appearance of Bellingeri's Dissertation.—In the sequel, Bellingeri reasons less accurately.

If, he says, "any one urge the objection, that it presides over involuntary motion in the internal ear, let him consult what we have said on this subject on the fifth pair; let him further observe, that there it forms a small ganglion, as takes place in the ciliary nerves. But since it also gives several branches, equally considerable, to the parotid gland, there will always be difficulty in this, that in certain places it is subservient also to involuntary motions and the actions of organic life. It must further be allowed to be subservient to the latter division of the animal frame, when it sends filaments to the mastoid cells, the tympanal membrane, the long limb of the anvil, round the jugular foramen, and the muscle inserted into the eustachian tube. . . As, therefore, the large portion of the fifth pair, in my judgment, is subservient to the functions of organic life, and its small

portion is dedicated to muscles of voluntary motion; so conversely, the larger portion of the seventh pair is devoted to the purposes of animal life, and its smaller portion to those of organic life."

Now, as Bellingeri grants three connexions of this nerve with the brain, it is probably on the few filaments which it derives from its third connexion, that these involuntary actions depend. Accordingly, he says "since its filaments seem to issue partly from the olivary eminences near the origin of the glosso-pharyngeal nerve, and, as filaments issuing from the olivary eminence contribute to the actions of organic life, it must follow that this character is applicable to the smaller portion [he should have said, to a few filaments] of the facial nerve." Doubtless the two greater portions which I described in 1809, are those on which sensation and motion respectively depend.

Bellingeri, therefore, properly concludes, that the facial nerve performs almost all the voluntary motions in the head, presides over the higher sensation in the face and neck, produces laughter, expresses the emotions of the mind and the passions of the soul, and is the agent of all the animal sympathies.

The power of this nerve, just described by Bellingeri, over physiognomical expression, is precisely that which Sir C. Bell, as one of his

discoveries, ascribed to it eleven years afterwards, as observed by the Edinburgh Reviewer!

THE AUDITORY NERVES.

The auditory nerves, or also seventh pair, like other nerves of pure sensation, have several terminations.

One termination of this nerve passes between the olivary and the restiform bundles, toward the floor of the fourth ventricle, after which it seems to bend upward, joining perhaps the peduncle of the brain which terminates in the hemispheres.—This is probably its perceptive termination; and therefore the removal of the hemispheres may well be injurious to hearing.

Hence Flourens makes the same observation with respect to hearing as he does to seeing, namely, that, when both hemispheres of the brain are removed, the animal becomes deaf; and the reporters to the French Institute on his enquiries likewise conclude, that the integrity of the cerebral hemispheres is necessary to the exercise of hearing.

Another termination is in a grey band which is placed transversely upon the restiform body, and which constantly covers a part of the base of the auditory nerve. Gall says it is the more swelled in every species, the larger the ears are, and the more acute the hearing is. In the horse, the stag, the sheep, it is as large as the

inferior tubercle.—The grey band appears to be a tubercle connected with the descending portion of the olivary bundles; and, in it, the connexion of the nerve is probably with involuntary motion.

Of this termination, the Wenzels state, that it is liable to no variety;* and that it is larger in mammalia than in man.†

A third termination is in the white striæ of the floor of the fourth ventricle, some of which from opposite sides sometimes join so as to form a kind of commissure.

* Constans contra ac perpetuum, nullique variationi obnoxium est.—*De Penitiori Structura Cerebri, p.* 188.

† Taeniolae majorum ex iis [mammalium nempe] absolute, omnium autem, quae examinavimus sine exceptione habita ad cerebri magnitudinem ratione manifesto insigniores sint, quam in homine.

Ratio istius longe insignioris magnitudinis cinerearum taeniolarum in citatis brutis in majori nervorum ad animalium istorum cerebrum ratione quaerenda esse videtur.—*Ibid. p.* 181.

Nervus acusticus tam in homine, quam in pluribus mammalibus et in variis saltem volucrum speciebus, quavis aetate atque utroque in sexu mediate, sive per descriptas modo ex cinerea substantia constantes taeniolas manifesto cum superficie quinti ventriculi conjunctus est, ita, ut nervus ille duplici modo cum ventriculis cerebri connexus sit; uno quidem per processum medullarem transversum, ex quo originem ducit, quatenus nempe ille inferiorem canalis infra corpora quadrigemina procurrentis parietem format; et altero per cinereas taeniolas.—*Ibid. p.* 192.

From the statements of the Wenzels, it appears that the white striæ in the bottom of the fourth ventricle are not always evident, and probably never appear before birth; that even when present, they do not always join the nerve, and, whether one or many, sometimes not one of them joins it, but disappear before they reach the more obvious commencement of the nerve, or seem to join the side of the ventricle above or below it; that even when some of them join the nerve, in most cases others do not, the latter being generally most numerous; that their diversity both in number and size is such that two brains seldom agree in these respects; that they have no uniform and certain origin, but sometimes join those of the other side in the middle line, or cross that line, or are connected with various parts of the bottom of the ventricle; and that often by means of a perpendicular section through the thickness of the oblong process to its opposite side, they may be seen to be continued downward; that their termination is often lost in the sides of the medullary substance; that in every respect they are subject to variety; and that in mammalia generally they are not to be found.

That any of these filaments join the nerve is a strong presumption that they are generally subservient to that purpose; and their not being seen in many cases to unite with it, should

not have surprised the Wenzels, considering the devious course which they themselves have described as to some striæ which after all yet joined the nerve.

That it is not very rare to find them wanting, only shows that sometimes one termination of this nerve, and sometimes another, is most decided and influential.

This is probably the proper cerebellic termination of the auditory nerve.

It is remarkably consistent with the views of this work, that while these white striæ are not apparent before birth, the grey bands forming, it would seem, the terminations of these nerves in the involuntary bundles, are to be found, as observed by the Wenzels, in the fœtus of three months.

THE HYPOGLOSSAL NERVES.

The hypoglossal nerves, or ninth pair, are attached on each side to the furrow which separates the olivary and pyramidal body, or to the fore part of the olivary tubercle; and their filaments generally combine in two bundles to form one nerve.

This nerve is evidently that on which the motion of the tongue chiefly depends, as its sense of taste depends on the lingual branch of the trifacial; and it is a remarkable confirmation of the doctrine of this work as to the use of

ganglia, that these two nerves here unite in the olivary body.

Bellingeri observes that this nerve, besides being distributed to the whole of the tongue and its muscles, and to the voluntary muscles which move the organs of voice, transmits also twigs to the diaphragm; and, as it is evident, that the hypoglossal nerve is subservient, in other organs, to voluntary motion, he infers, that in this distribution, it must perform the same function to the tongue, and that it therefore is the nerve for articulate speech, and modulated sound in singing—an inference which derives confirmation from the fact, that in fishes this nerve is wanting.

It further appears, that when the tongue is destitute of the faculty of articulation, taste may remain unimpaired; and conversely, from certain observations in which the lingual branch of the trifacial was wanting, that taste may be wanting, while the voluntary motion of the tongue remains.

In Müller's experiments, he found, that when this nerve was irritated or galvanized, violent convulsions of the tongue were caused. He also found, that when the nerve was cut, the animal, a cat, seemed to suffer pain; and hence he concluded that this nerve, although chiefly a motor, is also, in some degree, a sensitive nerve.

THE GLOSSO-PHARYNGEAL NERVES.

The glosso-pharyngeal nerves, or eighth pair, appear externally between the olivary and restiform bodies, forming at first a few distinct fibres, below the facial and above the following nerves.

These nerves have probably three connexions with the brain—one internally with the ascending bundles, and other two with the bundles between which they rest, namely the olivary anteriorly, and the restiform posteriorly or the filaments which descend in the form of a very broad flat band from the posterior part of the cerebel.*

* This band, as formerly observed, I described in 1809, and Rolando described it many years afterwards, under the name of arciform filaments. In his Recherches Anatomiques, he says " Si on n'a pas bien observé les cordons antérieurs de la moelle épinière [the lateral or olivary bundles of other writers] là où ils passent entre les corps olivaires et les pédoncules du cervelet, il faut l'attribuer en partie à la disposition singulière de filaments arciformes. Je désigne par ce nom des nombreux filaments médullaires qui paraissent sortir des fibres transverses de la protubérance, à l'endroit où les cordons antérieurs s'enfoncent sous elle. Les filaments arciformes couvrent en partie les dits cordons, ensuite, se tournant antérieurement, s'épanouissent et se répandent sur les éminences olivaires et sur les pyramides, et arrivent jusqu'au sillon médian qui les separe." With regard to these filaments, Rolando further observes, that frequently,

From experiment, Mr. Mayo thinks the branches of the glosso-pharyngeal to the tongue, are sentient only; and those to the pharynx, voluntary, and probably sentient also.

Though this is a sensitive nerve, Bellingeri observes that it is impossible to suppose it to be a nerve of taste, because, though its filaments are distributed to the papillæ, yet they are especially sent to the cup-like papillæ behind the foramen cœcum, where no taste exists.

In regard to the nerve being of the voluntary kind, Müller says that the glosso-pharyngeal, on the application of both galvanic poles, excites convulsions in the pharynx. These experiments accord with those of Desmoulins and Magendie.

This by no means excludes the involuntary action of this nerve. Bellingeri accordingly observes that the complete organic and involuntary character is communicated to the tongue by the glosso-pharyngeal nerve, which not only sends filaments to the whole pharynx, but to all the muscles of the tongue, its basis, body and apex. This accords with the vicinity of this

on account of the projection of the olivary bodies in man, their fibres divide, and one bundle passes above the olivary eminences and across the pyramids to their middle furrow, while another surrounds these bodies inferiorly by a more extensive curve, and forms what Santorini, Malacarne and others call the arciform processes.

nerve to the posterior portion of the olivary bundle on which involuntary action depends.

Its having a ganglion accords with its being sensitive as well as involuntary.

THE PNEUMO-GASTRIC NERVES.

The pneumo-gastric nerves, or also eighth pair, appear externally between the olivary and restiform bodies; forming also at first a few distinct fibres, sometimes arranged in two rows, below the glosso-pharyngeal and above the following nerve.

These nerves seem to me to have the same connexions with the brain as the glosso-pharyngeal, an internal sensitive connexion, the motive bundles on which they rest, and filaments which descend in the form of a flat band from the posterior part of the cerebel.

The branches of the pneumo-gastric nerve to the larynx, pharynx, and œsophagus, Mr. Mayo concludes are sensitive and motive. Müller makes the same observation. This accords with their having a ganglion.

THE ACCESSORY NERVES.

The accessory nerves, or likewise eighth pair, are attached to the spinal cord in the upper part of the neck by many fibrils at their posterior lateral part, not far from the posterior roots of the spinal nerves, which furnish a few filaments to them.

Rolando observes that, owing to the spreading of the inferior peduncles of the cerebel, the accessory nerves arise superiorly from these peduncles, and inferiorly from the posterior olivary portion.* Thus their origin is similar to that of the two preceding pairs.

From experiment, Mr. Mayo thinks the spinal accessory both sensitive and motive. This accords with their having a ganglion.

SUMMARY AS TO THE CHARACTERS OF THE NERVES.

All I have said shows of what importance is the character of nerves; as vital, or mental; involuntary, or voluntary.

The *nerve of vision* is one of higher mental sensation; and it is complicated with no other.

The *nervous apparatus of smell*, so far as it belongs to higher sensation (perhaps to respiration) is distinct in the olfactory nerve; but as belonging to the lower sensation of mere life, it is but a part of the general nerve, the trifacial, devoted to that purpose. Thus not only vital touch and taste, but vital smell, depends on this great vital nerve, the trifacial.

* Il est facile de comprendre, d'après ce que j' ai dit, que les racines supérieures, composées de plusieurs filets, sortent toujours des pédoncules inférieurs du cervelet, tandis que les racines inférieures naissent presque toutes de la partie postérieure des cordons antérieurs de la moelle épinière.—*Recherches Anatomiques*.

Of the *muscular nerves of the eye*, the 3rd is voluntary and involuntary ; the 4th involuntary ; and the 6th voluntary. Hence they are separate nerves.

The *trifacial nerve* is that of the vital system; and it includes both sensitive and motive bundles. Its sensitive bundles may be considered as fundamentally belonging to touch — touch in relation to the vital system, of which smell and taste in relation to the same system are mere modifications. Hence it performs the function of touch on the smooth surface of the skin ; of smell, on the mucous membrane of the nose ; and of taste, on the papillæ of the tongue. Its motive bundles are throughout of the involuntary kind.

The *masticatory nerve* belongs also to the vital system ; and it is a motive and voluntary nerve.

The *facial nerve* is one of the higher class at once including sensitive and voluntary bundles.

The *nerve of hearing* is one of higher sensation; and it is complicated with no other.

The *hypoglossal nerve* is that of the voluntary motion of the tongue.

The *glosso-pharyngeal*, the *pneumo-gastric* and the *accessory nerves* are the means at once of sensation and of voluntary and involuntary action.

Having, in the preceding pages, given, inde-

pendently of a new physiology of the brain and nervous system, a much more full and systematic account of their anatomy than I have met with elsewhere, omitting merely details as to the distribution of nerves, it remains only, in order to complete this most important division of anatomy, that I should, for these details of distribution especially, recommend to the reader Mr. Swan's "Demonstration of the Nerves of the Human Body," in which will be found whatever anatomical minutiæ as to distribution were deemed irrelevant to the more general purpose of this work.

APPENDIX.

BOUILLAUD AND FLOURENS. BELL, MAGENDIE, AND BELLINGERI.

"The honour of this discovery, doubtless the most important accession to physiological knowledge since the time of Harvey, belongs exclusively to Sir Charles Bell!"—*Report presented to the British Association, assembled at Cambridge, June* 1833. By W. C. Henry, M. D.

The reader who has perused my Preface, and who is, at the same time, aware that such sentences as that which I have just quoted, are scattered through a hundred volumes (although the discovery alluded to, is but an atom of what I had long before published, and that atom inverted, mutilated, and abused!) will not be surprised that my love of scientific pursuits should latterly have suffered some abatement.

To this, is owing the circumstance of my being, at the time when I began this work, unacquainted with the existence of some essays which, though written with particular and limited views, would yet have furnished striking support to my more general and extensive doctrines. Happily when such doctrines are well founded, every detached investigation becomes a new corroboration of their general truth.

I. The work of M. Bouillaud, entitled "Recherches Expérimentales sur les Fonctions du Cerveau en général, et sur celles de sa Portion Antérieure en particulier; Lues à l' Institut, en Septembre, 1827," is of value in this respect, especially in relation to the surface of the brain, to which experiment is most applicable, and on which its result is least equivocal.

1. The experiments of M. Bouillaud concur with those of M. Flourens in showing that the cerebral hemispheres are the seat of the *memory* of those sensations which are furnished by sight and hearing, as well as of all the intellectual operations to which these sensations may be subjected.* They even show, in this respect, that the removal of the brown substance of the convexity of the brain induces nearly the same phenomena as the removal of the hemispheres themselves.†

This, so far as experiments go, confirms the doctrine I had published eighteen years before, namely that the convolutions are the organ of memory.

* "Examinons maintenant quelles sont les conclusions que l'on en peut tirer, relativement aux fonctions de ces lobes. Certainement ils sont le siége de la *mémoire* des sensations qui nous sont fournies par l'ouïe et la vue, et de toutes les opérations intellectuelles auxquelles ces sensations peuvent être soumises." p. 6.

† "L' ablation de la substance corticale de la convexité du cerveau entraîne à peu près les mêmes phénomènes que la soustraction des lobes tout entiers." p. 31.

2. The experiments of M. Bouillaud also show that the removal of the anterior lobes does not destroy the internal affections, as impatience, anger, &c.*

This, so far also as experiments go, indirectly confirms the doctrine of this work, that these emotions depend on posterior parts of the brain.

3. The experiments of M. Bouillaud further show that the disorganization of the convexity of the hemispheres does not destroy external sensations,† and that the removal of the anterior lobes destroys neither sensation nor involuntary motion.‡

This affords an indirect but striking confirmation of the important view which I have taken as to *all the nerves of special sensation having one termination in the ganglionic tubercles placed upon the olivary or involuntary bundles,* namely that, *there, these nerves excite involuntary action, which is consequently unaffected by injury done to the superior parts*—a fact which explains all the ap-

* "Ces deux expériences (in removing the anterior lobes) prouvent incontestablement que la perte de certaines facultés intellectuelles n'entraîne pas nécessairement celle des sens, des affections internes, telles que l'impatience, la colère, &c., non plus que celles des mouvemens instinctifs." p. 25.

"Ils sentent, voient, entendent, odorent; ils s'effraient facilement, s'impatientent, quand on les contrarie." p. 42.

† "La désorganisation de la convexité des hémisphères cérébraux détermine un trouble profond dans les phénomènes intellectuels, sans détruire les sensations externes." p. 15.

‡ See note preceding the last.

parent anomalies of this kind which have puzzled the mere and unreasoning experimenters on living animals.

II. From Dr. Henry's "Report to the British Association," I find that, in some of the experiments of M. Flourens* on the semicircular canals of the ears of birds, "division of the horizontal canals on each side occasioned a rapid horizontal movement of the head from right to left, and back again, and loss of the power of maintaining an equilibrium, except when standing, or when perfectly motionless. There was also the same singular rotation of the animal round its own axis which follows injury of the crura cerebelli.—Section of the inferior vertical canal on both sides produced violent vertical movements of the head, with loss of equilibrium in walking and flying. There was in this case no rotation of the body upon itself, but the bird fell backward, and remained lying on its back.—When the superior vertical canals were divided, the same phenomena were observed as in section of the inferior, except that the bird fell forward on its head, instead of backward.—All the canals, both vertical and horizontal, having been divided, in another pigeon, violent and irregular motions in all directions ensued."

* Memoires de l'Académie des Sciences, Tom. ix. p. 454.

1. On this, Dr. Henry remarks that "no explanation is proposed by Flourens of the control thus exercised by a nerve supposed to minister exclusively to the sense of *hearing*, over *actions* so entirely opposite in character."—In pages 223 and 224 of this work, I have, however, shown that hearing is the sense which excites the passions (as touch does ideas, and sight emotions), and which therefore most naturally and directly produces muscular action.

2. Dr. Henry also says "it is remarkable that the irregular movements should observe the same direction in their course as the canals, by the section of which they are induced. Thus the direction of the inferior vertical canal is posterior, that of the superior is anterior, corresponding perfectly with the directions of the abnormal motions."—In pages 203, *et seq.* of this work, I have shown that such precisely must be the directions of vibrations affecting the nerves in these canals; and it is to these minuter motions therefore that those of the body correspond in these experiments.

3. The reader will observe that, in the same way, I explained the motions of the body, in those experiments in which parts of the brain and cerebel are divided; and these cases as to the ear afford a striking coroboration that the directions which I then assigned to the motion or function of those cerebral and cerebellic

parts as the cause of external action, was accurately true.

Such are the conclusions (of a mere corroborative kind, be it observed) which all who study structure and embrace enlarged views may sometimes derive from experiments which, as in the last case of M. Bouillaud, and in that of M. Flourens, those who make them do not understand. And this is the general case of these experimenters. They make their little experiments, because they have no enlarged views; and for the same reason, they do not understand them when made. These experiments could not indeed be either understood or trusted to, without those enlarged views which, to higher intelligence, supersedes their necessity.

III. Of the dissertation of Bellingeri on the trifacial and facial nerves, I had some account just before writing the last chapter of this work, which treats of these nerves; and I could not help being gratified to find that, limited as were its subjects, it was so entirely conformable to the doctrines of this work, and so opposed to the hypothesis which forms a mere inversion of a small portion of these doctrines, that, without any knowledge of what Bellingeri had done, I had, even at the beginning of the work, treated these nerves in a similar way.

I recur, however, to that dissertation, in order to show that, as all particular and limited views

furnish support to more general and extensive doctrines when these are well founded, so do all of them tend to expose and destroy false hypotheses. This is strikingly exemplified in the effects which the dissertation alluded to has recently produced on Sir C. Bell's borrowed and blundering hypothesis, and the new exposure it has led to.—This being a little matter, we may employ a little type in discussing it.

It appears that Bellingeri's admirable dissertation on the 5th and 7th pairs of nerves has been in the library of the Royal Society ever since 1820; that Sir C. Bell had access to it, as a member of that society; and that he partially adopted views similar to those which it contains, while he affected, and still affects (for there lies the ill) a tone of originality.

In the last No. accordingly, of the Edinburgh Medical and Surgical Journal, another grave accusation was brought against him on that account.

The alleged abstractions from Bellingeri have again brought conspicuously into notice those from Magendie, which appear to have been concealed or obscured, only by the acclamations and eulogies of Sir C. Bell's friends.

The fact is that, in their joint doctrine which I have shown to be a plagiarism, an inversion, and a blunder from my own, as false in all respects as it is dishonest, Sir C. Bell began the *plagiarism*; but, not venturing far enough at first, he merely suggested, and was anticipated in, the *inversion* by Magendie; while, as in all such scrambles, both perpetrated the *blunder*, and each now contends for the honour of having accomplished the whole!

I have treated this as the act of Sir C. Bell, because he

certainly originated the plagiarism; because he contends at least for having first made the inversion; and because he shares equally in the blunder.

It is now necessary to view this subject in the new and additional light which has so recently been thrown on it. I shall endeavour to do this with the utmost possible brevity consistent with presenting to my readers the facts and the information which the subject affords.

I have already observed that Galen and the ancients knew nothing of these matters, for they assert that nerves of motion exercise the sense of touch (the basis of all sensation!), and that the same nerves may, according to their softness or hardness at various parts, minister at once to sense and to motion! which is in direct opposition to truth.

Willis's statement that "nerves serve either for sense, or motion, or both together" is nothing to the purpose—nobody ever doubted that; and he committed the ancient error when he talked of "the *hard* portion of the fifth nerve being *rather* for motion than sense," of "the nerves of the fifth serving for the exercise of *either* faculty," &c.

Van Swieten's statement "that some nerves serve for the sense of feeling, and others for motion, which, though they are very different in their origin within the brain, yet being collected into the greater trunks of the nerves, are sent together to the different parts of the body; wherefore the functions of the motory nerves may be hindered, while the nerves for feeling remain quite unhurt, or at least not so much, and the contrary," is rather more to the purpose; but it is still far short of "the modern doctrine," as shall forthwith be shown.

It is really surprising that so many persons should have written on this subject, and that every body should speak about it, without anything like a clear understanding of it.

Even an agent of Sir C. Bell, his brother-in-law and assistant, or, *properly speaking*, *Sir C. Bell himself*, for he

makes no personal reply, has in a late number of the Medical Gazette,* declared that "The fundamental principle which pervades every sentence of Sir C. Bell's works, is this, that a single nerve cannot bestow both motion and sensation. The former endowment infers a nervous influence propagated outwardly from the brain to the moving parts; while the latter infers an influence conveyed in a directly opposite course—that is, from the sentient surface inwards to the sensorium. These two properties, he concluded, were incapable of existing together in the same nerve; whenever they are combined, it is a sign that the nerve is compound—that it originates by two distinct roots from the brain or spinal marrow."

Now, if Sir C. Bell's works contained the discoveries alluded to, and this were their fundamental principle, it would in no way differ from the first clause of the preceding quotation from Van Swieten's Commentary on Boerhaave's 1057th aphorism! and Van Swieten would accordingly be the originator of these discoveries, the founder of the modern doctrine! It is odd enough that Sir C. Bell should not see this.

The fundamental principle of the modern doctrine, however, is far more than this, or it is nothing at all.

The modern discovery is two-fold:—

1st. "That (not merely distinct nerves, but) distinct nerves, spinal bundles, and cerebral masses, are appropriated to sensation, and that other nerves, spinal bundles, and cerebral masses, are appropriated to volition."—It would be foolish to pretend that either this or anything like it was stated by any writer, previous to the discoveries in question; and if any one were to make such pretence, the short reply would be "let him produce the statement."

2ly. That it is the anterior or abdominal nerves, columns, and masses that are appropriated to sensation, and

* "Question of the Originality of Sir Charles Bell's Discoveries in the Nervous System, by Alexander Shaw, Esq.," in its 42d No. for July 19th, 1834.

the posterior or dorsal nerves, columns, and masses that are appropriated to volition, &c.—Or, as inverted by Messrs. Magendie and Bell, " That it is the dorsal nerves, columns and masses that are appropriated to sensation, and the abdominal nerves, columns and masses that are appropriated to volition !"

It was first shown by Mr. Mayo, that Sir C. Bell, in his pamphlet privately printed in 1811, " inferred that the anterior and posterior roots of the spinal nerves have different functions; but in the nature of their functions he was mistaken. Upon the anterior root, he supposed both sensation and motion to depend: the posterior root he considered an unconscious nerve, which might control the growth and sympathies of parts. *Before Mr. Bell published any other account of the functions of these nerves, Magendie had given to the world the true theory of their uses.*"

In his " Journal de Physiologie," for 1822, page 276, Magendie's paper entitled " Expériences sur les functions des racines des nerfs rachidiens," is inserted, and after there relating his experiments, he concludes " I can at present advance as positive, that the anterior and the posterior roots of the nerves which arise from the spinal marrow have different functions, that the posterior appear to be more especially destined to sensibility, whilst the anterior appear to be more especially connected with motion"—" il me suffit de pouvoir avancer aujourd'hui comme positif, que les racines antérieures et les postérieures des nerfs qui naissent à la moelle épinière, ont des fonctions différentes; que les postérieures paraissent plus particulièrement destinées à la sensibilité, tandis que les antérieures semblent plus spécialement liées avec le mouvement."

This, I really believe, is the very first appropriation, in any work, of sensation to the posterior and motion to the anterior nerves. I have again looked at Sir C. Bell's books with a view to discover any similar announcement of prior

date; and I can find nothing of the kind. The planner of the operation was not sufficiently bold; and his participator, unconscious, I readily allow, of ill-intent, stepped in before him. M. Magendie therefore first made this simple inversion.

But what now* says Sir C. Bell?—Why, that M. Magendie has in some measure given up this view, and adopted a different one; and, as he can't be of two opinions at the same time, therefore, he, Sir Charles, adopts the one just now stated, as his own!—This is obviously a mere shuffle!

But, let us see how far M. Magendie now qualifies this opinion.—Like an honest man, always open to conviction, in consequence of finding, contrary to his expectations, that, in the higher animals, whose functions bear most analogy to those of man, some degree of sensation always accompanies an injury of the anterior nerves, and some degree of motion, an injury of the posterior nerves, M. Magendie, in a subsequent paper in the same volume, page 336, entitled "Expériences sur les fonctions des racines des nerfs, qui naissent de la moelle épinière" felt himself bound, in spite of his love for the simple doctrine as he had first stated it, to acknowledge "that sensation is not exclusively in the posterior roots, nor motion exclusively in the anterior"—"que le sentiment n'est pas exclusivement dans les racines postérieures, non plus que le mouvement dans les ántérieures."

O! says Sir Charles, *I* call this opinion *exactly the opposite* of your former opinion; and as you can't have two opposite opinions, your former opinion is now mine, or that of anybody who chooses to appropriate it, just as perfectly as if you had never held it!—In vain, M. Magendie asserts that he holds it still, with the very slight modification which he owes to truth.—No, no, says Sir Charles, we are directly opposed, &c.

* See his paper just referred to.

In the paper alluded to, Sir C. Bell expressly says, that M. Magendie's opinions are "diametrically *opposed* to those of Sir Charles Bell! The French physiologist does not lay claim to any discoveries of Sir Charles Bell. [Sir Charles is skilled at inversions! It is, in this case M. Magendie who precedes, and Sir Charles who lays claim!] What Magendie claims, is the merit (if such it be) of adopting a view of the functions of the roots of the spinal nerves *directly hostile* to that maintained by *our English* physiologist. [How winning! No wonder Sir Charles does not like to write thus in *propria persona!*] . . . It is not on a question of rival claims for the same discovery that these physiologists are divided: the point is, whether one opinion, originally set forth [an utter falsification!] and still supported by Sir Charles Bell, or another, which has been placed in opposition to it by M. Magendie, is the correct one . . . Sir Charles Bell's opinion is, that the posterior root, which has the ganglion formed upon it, is for sensation, and exercises no power *at all* over the muscles—that the anterior root, which has no ganglion on it, but resembles in this respect the ninth, &c., is for motion *alone*, and has nothing whatever to do with sensation . . . But what does Magendie maintain? In controversion of this distinct announcement, he has insisted, that the two roots do not respectively possess this simple character; he pretends that *both sensation and motion* reside in each of the two different roots. [Yes, but he, as well as others, would allow that this is done through distinct fibrils; and nothing at first sight forbids the supposition.] . . . Since, therefore, he maintains a view, the direct tendency of which is to subvert the truth of the principle which runs through the whole course of Sir Charles Bell's investigations, how can it be said that he claims that gentleman's discoveries?"

This is, in effect, to tell us, that the date of Sir C. Bell's alleged discovery is of little consequence; that though he gives up his previous doctrine of sensation and motion both be-

longing to the anterior column and nerves, yet he does not exactly adopt Magendie's statement; that instead of saying that sensation belongs *especially* to the posterior, and motion to the anterior, columns and nerves, he says they belong *entirely* to them; that this *differs* from Magendie's doctrine, and therefore is *not the same;* and that Sir Charles cannot consequently be said to have borrowed Magendie's views!

Will not the profession in England indignantly repudiate such conduct, even as to M. Magendie! What man is safe if it be countenanced!

It may perhaps be imagined that M. Magendie errs in allowing any degree of sense to the anterior, or of motion to the posterior, nerve. But, though his experiments were most carefully conducted, he had perpetual evidence of this, in the higher animals. These experiments were performed with great care, and often repeated: still, in mammalia, this was the uniform result.

As to the experiments of M. Müller, of Bonn, which are brought forward to correct those of Magendie, and of which Sir C. Bell says, "The experiments upon the roots of the spinal nerves have been made by this distinguished German physiologist with so much care, and such ingenious contrivances to avoid error, that no doubt can be entertained of their perfect accuracy,"—of these, it is enough to say that, while M. Magendie's experiments were made upon the higher animals, those of Müller were made upon *frogs!* in which the nervous system is so essentially different that the cerebel is absolutely wanting, there being in lieu of it a mere commissure of the fourth ventricle, and the spinal cord is enormously encreased in proportion to the brain, and therewith its connexions, their reciprocal influence, &c.

I need not add, that it would be monstrous to assert, that because M. Magendie honourably avows that his experiments do not, in some respects, support his principle, therefore, Sir C. Bell, *who protests against all experiments,* as

not only *useless* but *mischievous*, has a right to seize upon M. Magendie's principle as his own!

It appears perfectly clear that Sir C. Bell retained his first opinion, and did not even follow M. Magendie in appropriating sense to the posterior and motion to the anterior nerves, until two or nearly three years after M. Magendie's first distinct and decisive publication.

In a paper read to the Royal Society in July 1821,* he indeed spoke of two systems of nerves, one simple and uniform, the other irregular and complex; but he defined all the nerves of the spine without distinction,† and several others, to constitute the original and symmetrical system, and those which he calls respiratory nerves, to constitute the irregular and complex system.‡

In the text of this very paper, p. 62, he says " all these nerves [the spinal, &c.] agree in these essential circumstances; they have all double origins; they have all ganglions on one of their roots; they go out laterally to certain divisions of the body; they do not interfere to unite the divisions of the frame; *they are all muscular nerves*, ordering the voluntary motions of the frame; *they are all exquisitely sensible*," &c. Here, instead of a distinction into nerves of sensation and nerves of volition, he expressly declares that all the spinal nerves are at once muscular and sensible. And this is perfectly conformable with his supposition in 1811, that sensation and motion depend on the same parts; and it shows that, in 1821, he held the same opinion.

To make this still clearer, he goes on to contrast the sensibility, not of the posterior with the insensibility of the anterior roots, but the sensibility of the nerves of his original class, including all the spinal nerves, with the insensibility of his respiratory nerves. " Those of this class [the original]

* See his Nervous System, page 55.

† Page 62. ‡ Page 64.

exhibit," he says, "the highest degree of sensibility; while on the contrary, nerves not of this original class or system are comparatively so little sensible as to suggest a doubt, whether they be sensible in any degree whatever."

In the whole of this paper, presented to the Royal Society in 1821, not one word indicates a glimpse of any such distinction as that soon after published by M. Magendie.—As to discussions on the differing functions of the 5th and 7th, they imply nothing of the kind; and they were better conducted by Bellingeri long before this, without even his having any correct knowledge of the spinal nerves, as will be seen when we consider Sir C. Bell's unacknowledged obligations to that writer for all that he has not borrowed of myself or of M. Magendie.

Sir C. Bell's paper presented to the Royal Society in 1822, is equally devoid of all indication that he then followed M. Magendie, or shared his opinion.* As observed accordingly by the Edinburgh Journalist,† "M. Magendie conceded the point, that the English physiologist had the merit of showing that the fifth nerve is one of sensation, and that the motions of the face depend on the portio dura.‡ In making this concession, however, [as to what is now proved to be the property of Bellingeri!] the French physiologist denied that, previous to his own time, any general distinction had been taught between nerves of sensation, and nerves of motion; and maintained, that he was the first who showed, that, of the double row of spinal nerves, the anterior are for motion, and the posterior for sensation."

The same Journalist has also observed, that "Sir C. Bell's inferences as to the fifth pair being at once nerves of sensa-

* Those, however, who want to see these papers without subsequent additions, must not consult the 4to. book of 1830.

† No. for July.

‡ Points which, it will presently be seen, Sir C. Bell borrowed of Bellingeri, misunderstanding, however, and mutilating them.

tion and voluntary motion [borrowed though they are from Bellingeri] have required to be rectified by the experiments of Mr. Mayo, who showed, by dividing in an ass the portio dura, not on one side but on both, that this is a nerve of voluntary motion only; and by similarly dividing the second and third branches of the fifth, at their points of emergence in another ass, that the lips were deprived of sensation, but not of motion. The same anatomist aided by dissection, reasoning, and experiment, and observing that the masseter, temporal, two pterygoids, and circumflexus receive no branches from any nerve but the fifth, and yet receive them from the ganglionic portion of that nerve, concluded that almost all the branches of the ganglionic portion are nerves of sensation, while those of the ganglionless portion are nerves of motion."*

In short, there is not the slightest proof that Sir C. Bell even followed M. Magendie, in appropriating sensation to the posterior, and motion to the anterior, spinal nerves until he republished his papers to the Royal Society, in 1824. Can any thing, then, be more disgraceful than an attempt to lay claim to priority in this respect.

But we have now to witness another and a new exposure, and another shuffling and disgraceful defence.

With this view, the beautiful observations of Bellingeri, which will amply reward the reader's perusal, should first be referred to, in the description already given of the trifacial and facial nerves.

In the Dissertation, of which I formerly gave the title, and which was published in 1818, Bellingeri, displaying extensive and accurate observation, profound and beautiful reasoning, and able experiment, gave an unrivalled description of

* Nor do Sir C. Bell's failures end here. His doctrine as to a connexion subsisting between the seventh and the associated motions of respiration, or what he termed the instinctive motion of the face, has been contradicted by the experiments of Fodera and Mayo.

the 5th and 7th pairs of nerves, in which he proved that the greater portion of the 5th is not merely a nerve of sensation but one of involuntary motion, because (an irrefragable argument) it exclusively supplies secreting and involuntary parts; that its smaller portion is a mere muscular nerve; and that the 7th is not merely a nerve of motion but one of sensation, because (which is equally irrefragable) it has various roots, and most minutely supplies an extensive sensitive surface.

Thus Bellingeri, so far back as the year 1818, showed, with regard to the fifth pair, that its greater portion performs vital and involuntary functions, and that its smaller portion, principally if not exclusively, governs muscular action; and with regard to the seventh pair, that it performs animal and voluntary functions.

Having, however, given a detailed view of Bellingeri's doctrine as to these two nerves in the preceding chapter, I may briefly lay before my readers the particular observations of the Edinburgh reviewer, which have created so extraordinary a sensation throughout the profession. Without the statement of these, and of Sir C. Bell's extraordinary defence, my own comments would not be intelligible.

"It is altogether unnecessary, says the writer, as to these two nerves, to point out to our readers how completely Bellingeri has anticipated, by several years, all the physiologists [Bell, Mayo, &c.] who have devoted their attention and inquiry to this subject. We have no doubt that every one who peruses the dissertation with attention will be satisfied, that the Italian has given a much more clear and connected view of the anatomical and physiological history of these two nerves, than any one of the writers who have yet attempted the task."*

* Such admirable works as these were the foundation of Hildenbrand's unequivocal testimony to the originality and precedence of Bellingeri's labours:—" Qui hancce Neurophysiologiae partem hodierno aevo excoluerunt, viri eximii, Bell, Magendie, Rolando, aliique, posteritatis gratitudinem sibi

As to the smaller portion of the fifth, and the assertion made by Sir Charles Bell, in his second paper on the nerves of the face, communicated to the Royal Society on the 28th of May 1829, that "in no author is the anatomy of the motor nerve traced with sufficient minuteness, in regard to the distinct uses of the muscular and sensitive divisions," the reviewer observes, "from this statement every reader must infer, that no description of this nerve, as a pure motor agent, existed before Sir Charles Bell gave the one which we must presume he wishes us to regard as not only the first, but the most minute and accurate. It is nevertheless, a very remarkable fact, that the present dissertation, published actually eleven years before the paper of Sir Charles Bell was read to the Royal Society, contains not only a most minute and accurate description of this motor division of the fifth pair, but one which is greatly superior to that in the Transactions in accuracy, precision and method." And "from all this it will result clearly, that the description given as original in the transactions of the Royal Society in 1829, is not only *not original*, but is greatly behind the Italian description of 1818, in accuracy and minuteness."

"We have also to mention that the description which Sir Charles Bell gives of the nerve which he denominates buccinalis labialis, and which is the bucco—labialis of Chaussier and Bellingeri, is completely anticipated by the latter author. Indeed, how Sir Charles Bell can pretend to prefer the claim of distinguishing this as a manducatory nerve, is to us quite incomprehensible, when Bellingeri, in the year 1818, applied to it the denomination of nervus masticatorius, and main-

omnino vindicant. Singularis vero laus debetur clarissimo Bellingerio, cujus amicitiam honori duco. Indefessus iste naturæ scrutator, Taurinensium medicorum decus, primus sane fuit, qui nervorum cerebralium functiones haud communi pervestigabat ἀκριβεια, atque differentiam essentialem inter nervos motorios et mere sensitivos validissimis evicit argumentis, teste pulcherrima dissertatione, quam anno 1818 typis edidit."

tained positively that it was entirely subservient to the muscles of mastication."

These three paragraphs quoted from the Review, were necessary to understand the *coup de grace* given as follows:—

"The most extraordinary part of the business is, that the views of Bellingeri should have been so long unknown and overlooked, that his claims to discovery should have been disregarded, and that, in all the discussions relative to this subject, his name is never once mentioned.

"All this has an appearance so much the more unfavourable for *this country*, that the author sent to the Royal Society of London in 1819, a copy of the dissertation now before us, and that it was presented to that learned body on the 20th of January 1820, as is proved by its being acknowledged at that date among the list of donations. There, however, it appears to have been either buried in the inglorious oblivion of the multitude of works which find their way into that far famed institution, or,——*but no, we cannot allow ourselves to give utterance to the alternative.* Is this, we beg to ask, the treatment awarded to scientific foreigners by the Royal Society of London!—Is this the encouragement given to long, patient, and assiduous inquiry, to learning and knowledge of a subject almost unrivalled, to genius, we may say, rectifying errors, reconciling discordances, bringing order and method out of confusion, and facilitating the labours of the future generation, by the establishment of a series of beautiful general deductions!

"It must be rather mortifying for Sir Charles Bell to find, that, while on one hand, Magendie lays claim to his discovery of the different functions of the anterior and posterior roots of the spinal nerves, and concedes to him the merit of distinguishing the sensiferous faculty of the larger portion of the fifth pair, and the motiferous faculty of the small portion, and of the seventh pair,—on the other, the just claims of M. Bellingeri deprive him even of any title to the latter

discovery; and the dissertation of that author affords abundant evidence that he had, in 1818, explained the whole of these distinctions in the clearest manner.

"The only parallel situation which we can remember is that of the old Abbot, who, when told that some person had before said all that he was now saying, addressed his remembrancer in the following characteristic language: '*Pereant illi qui ante nos nostra dixerunt!!!*'

Now, what says Sir C. Bell to this grave accusation? Does he come forward and answer it like a man? No; he nominally employs another to answer it, and he tries to hide his own head during the storm!—It is unnecessary to say that had Bellingeri been in England, he would of course have considered the answer as Sir C. Bell's—as that of the only person interested in so answering. Nor is any man honoured by being made a substitute in such a case.

And what, then, says Sir C. Bell? Why, he accuses those who expose these things, of a "spirit," an "animus," a desire "to hurt Sir Charles [himself] in the eyes of the profession!" And he appeals to the sympathy of Englishmen, by calling himself *our* physiologist, and by terming those whom *our* physiologist has been taking liberties with, mere *foreigners!* And he shuffles and shifts and evades and quibbles—not like an Englishman!

"Founding on this principle [that is the principle which Mr. Swan had, in the same number of the Medical Gazette, shown to be Van Swieten's!], Sir C. Bell announced," says he, "the functions of the two principal nerves of the face and head — the fifth, and the portio dura of the seventh.

"The fifth pair arises from the brain by two distinct roots, one having a ganglion formed upon it, while the other has not; and in accordance with the principle above stated [Van Swieten's], he said that this is a double nerve; in virtue of its two distinct roots, it possesses two sepa-

rate functions; it is at once the nerve of sensation to all the head, and the motor nerve of the muscles of mastication.

"The portio dura, however, is of a totally different character from the fifth; it has only one root, and has no ganglion near its origin: this nerve has, accordingly, but one function—it is a motor nerve; it can carry a mandate only outwards to the muscles; it has no power of carrying a sensation inwards.

"These opinions received the fullest and most unquestionable confirmation from experiments upon living animals, performed by Sir Charles Bell himself, and also by his zealous assistant in all these pursuits, the late Mr. John Shaw."

As to the 5th, Sir C. Bell here mistakes the two great trunks of the nerve for its roots! He ought to know that Soemmerring has shown it to have connexions with the cerebral peduncles and with the floor of the fourth ventricle, that Rolando has traced the latter connexion to the inferior peduncle of the cerebel, and that Santorini, Gall, and Tiedemann have traced a third to the olivary body! There is, in this, nothing inconsistent with this nerve's exciting involuntary actions, as well as being a nerve of sensation, precisely as Bellingeri has stated. But independently of all account of its various connexions with the brain, which we might or might not have known, we absolutely see it supply secreting and involuntary parts, and we therefore know that it must excite involuntary action, and that Bellingeri is right in asserting that it does so, as well as conveys sensation. Cannot Sir C. Bell also see that all gangliated nerves perform a double function; as those of the viscera, which not only convey the impressions made by their contents upon their sides from these sides to their nervous centres, but also, by other fibrils returning, excite the reaction of these sides upon their contents, and the due performance of their functions. No experiment can affect this, either as to the fifth or the branches of the sympathetic.

As to the portio dura, Sir C. Bell displays similar unacquaintance with facts, as it has been shown to have two, if not three, perfectly distinct roots. And as to its having no power to carry sensation inward, Mr. Mayo allows it to be in some measure sensible; M. Magendie says it is *very* sensible; and physiologists in general agree with Bellingeri in this respect. Besides, its extensive distribution to the skin of the head and face can be accounted for in no other way. Finally, Bellingeri's experiments (far more to be depended on than Sir C. Bell's, as we shall soon see) prove it to be a nerve of sensation.

Unacquaintance with facts and unwarrantable assertion having done their duty, let us now see what that for which there is really no other name than shuffling, will do under these circumstances.

" Now," says Sir C. Bell, " although Bellingeri made no experiments of any kind upon any part of the fifth, yet it is to be conceded that he was acquainted with the true physiological character of the lesser root. But he was indebted for this knowledge to one of his countrymen ! He only repeated the assertion of another Italian in a neighbouring school,—I mean Palletta. It was this anatomist who first suggested (1784) that the anterior portion of the fifth pair, which he termed nervus crotaphitico-buccinatorius, and showed was distributed exclusively to the muscles of the jaws, must be a nerve of motion. He pointed it out to be the nerve which is affected in trismus. Neither has Sir Charles Bell omitted to give the credit due to Palletta for this observation."

It is painful to record extremes of disingenuousness. But while the excellence of Palletta is here brought forward as a cover for the plunder of Bellingeri, yet in the Preface to Sir C. Bell's Nervous System, p. ix., we have this passage, " Palletta, after the discovery of these branches of the fifth pair to the muscles of the jaw, and just as one would expect that he was about to expound the truth, adds, that for the

other branches of the fifth nerve, he does not know what to make of them!"—This, however, is exactly what Bellingeri did know; and had explained eleven years before Sir C. Bell wrote on the subject.

It is a fact that Palletta did nothing upon this subject worthy of being named in the same day with the labours of Bellingeri. And if he or any other person did, why did Sir C. Bell, in his Paper of 1829, say that "in no author is the anatomy of the motor nerve traced with sufficient minuteness, in regard to the distinct uses of the muscular and sensitive divisions!" Bellingeri admirably distinguishes and explains these divisions. And why was not Bellingeri named?—Because it would have betrayed the source from which Sir Charles' knowledge of the fifth and seventh nerves was derived, bad as is the use he has made of them.

"Sir Charles Bell," says he of himself, "affirms that this larger root is dedicated entirely to one single office, viz. that of *sensation*. M. Bellingeri, on the other hand, pretends that, besides conferring sensation and numerous other qualities usually assigned to nerves, *it regulates the actions of the muscles of the face*."

It is unfavourable to Sir C. Bell's doctrine that the greater portion of the fifth should be allowed to have anything to do with motion, and that the seventh should have anything to do with sensation, and though he adopts Bellingeri's doctrine in every other respect, as to the sensation of the greater portion of the fifth, the motion of the smaller portion, and the voluntary action of the seventh, Sir Charles has the same sophistry at hand.—His doctrine *differs* from Bellingeri's; it is *not quite the same*; and therefore he *cannot be said to have borrowed it!*

This is a repetition of the trick played to Magendie. Sir Charles does not, in either case, adopt the whole; and as a part and the whole are two different things, how can "our" Sir Charles be said to have borrowed the "foreigner's"

opinions! Nay more than all this, when a whole and a part of any opinion are adopted by *opposite* and opposed parties, they are *opposite* opinions! How then can "our physiologist" be said to have borrowed the *opposite* opinions of these opposed "foreigners!"

As then, in regard to the functions of the fifth and seventh pairs, Bellingeri, in 1818, showed, that the greater portion of the fifth is a nerve of sensation (and, as it exclusively supplies involuntary parts, of involuntary action); that the smaller portion is a nerve of mastication; and that the seventh is a nerve of voluntary action (and, as it supplies a most important portion of the skin, and has several roots, of sensation also): it will not be tolerated that Sir C. Bell, because he objects most groundlessly, as I have proved in the account of these nerves, to the functions mentioned in the parentheses above,* should lay claim to the rest as his own; and *that* eleven years (viz. in 1829) after the admirable account given of all of them by Bellingeri!

"I have already mentioned," says Sir Charles of himself, "that Sir Charles Bell related experiments to corroborate what he stated. *M. Bellingeri has not been at the pains to make a single experiment!*"

This is really too bad! It almost refuses comment.

"But," says Sir Charles, "it is not to be supposed that this principle—that a single root bestows only one function [Van Swieten's principle!] rested altogether upon the experiments on the nerves of the face. It was not with these nerves that Sir C. Bell began his investigations! It is well known that *he commenced by experimenting on the spinal nerves.*" . . ." When we speak, therefore, of the validity of the proofs by which he established that the fifth pair is a double nerve—the nerve of sensation and mastication—we must not omit to take into consideration *the experiments on the spinal nerves which corroborated his conclusions.*"

* They are those which happen to be unfavourable to his views.

This, I cannot help saying, is a most disgraceful shuffle.—In his Nervous System, pages xxiii, 31, &c. Sir Charles acknowledges his having repeatedly stated that he left his experiments on the *spinal nerves* to prosecute the subject by observations and experiments on the *fifth pair*, because he found it *impossible* to arrive at a decided *conclusion* by means of *the former!** And now he in effect says "O you talk of my borrowing as to this paltry fifth pair; but you forget my experiments on the *spinal nerves!*—In page 109 of his Nervous System, Sir Charles, speaking of the ganglia as *signs* of sensibility! says his experiments on the fifth pair made certain "what could only be assumed [not proved] from the experiments on the spinal nerves."—In other words, he acknowledges that his experiments on the spinal nerves were worthless! And that I do not exaggerate in saying they were worthless, is proved by his own words, page 218, "Experiments have *never* been the means of discovery"—nay he adds "the opening of living animals has done more to perpetuate *error* than confirm the just views taken from anatomy!" But now he says in effect "don't forget my experiments on the *spinal nerves* which *corroborated* my conclusions! I am the man for experiments! That 'foreigner' Bellingeri did not perform one!"—I think I am warranted, then, in calling this a most disgraceful shuffle; and every fair disputant, I believe, will so deem it.

But I will venture to add no more, lest indignant feeling and the sense of an injury which has been of long duration, should induce me to commit personalities—a resource of the guilty and injuring, not of the injured.

* "The impossibility of arriving at a decided conclusion regarding the sensibility of these roots, was the reason why he left his experiments as we find them, to prosecute the subject by observations and experiments on the fifth pair."——"I was deterred from repeating the experiment," &c. &c.

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